

APRIL 1960



VOL. 52 • NO. 4

Journal

AMERICAN
WATER WORKS
ASSOCIATION

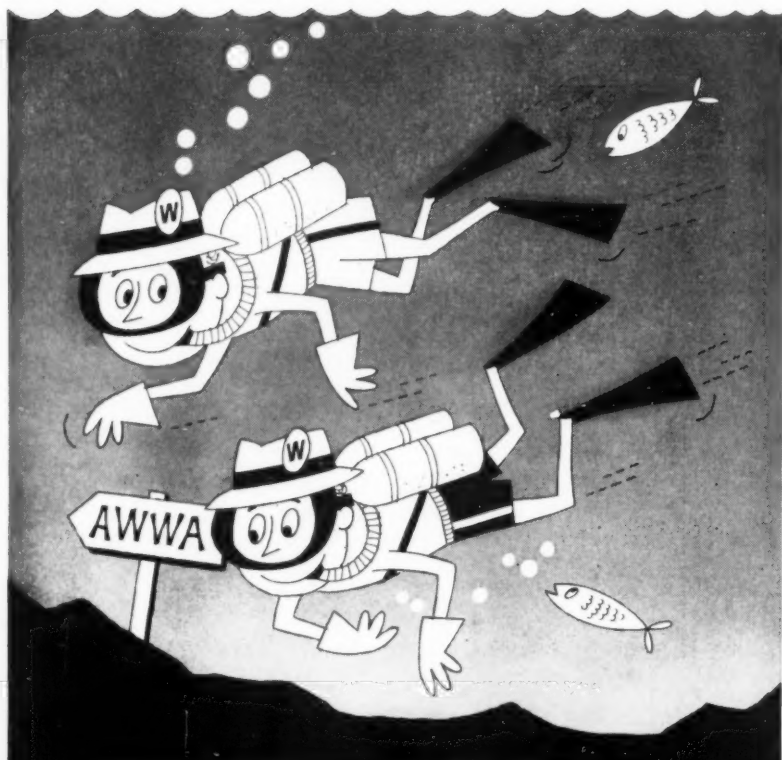
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Journal

AMERICAN WATER WORKS ASSOCIATION

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April 1960

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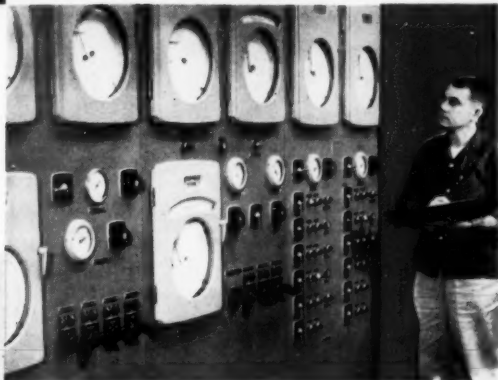
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AWWA ANNUAL CONFERENCE**Bal Harbour, Fla.****May 15-20, 1960**

See April Willing Water for complete program.

*Coming Meetings***AWWA SECTIONS****Spring 1960**

Apr. 20-22—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, J. J. Rossbach Jr., Civ. Engr., Metropolitan Utilities Dist., 3906 N. 48th St., Omaha.

Apr. 20-22—Kansas Section, at Broadview Hotel, Emporia. Secretary, H. W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina.

Apr. 22—South Dakota Section, organization meeting, at Union Bldg., South Dakota State College, Orangeburg. Acting Secretary, J. D. Bakken, Chief, Water Sanitation Sec., State Dept. of Health, Pierre.

Apr. 22—California Section, at Mark Thomas Inn, Monterey. Secretary, R. E. Dodson Jr., Supt. of Water, Dept. of Utilities, Balboa Park, San Diego.

Apr. 24-27—Canadian Section, at Statler Hotel, Buffalo, N.Y. Secre-

tary, A. E. Berry, 72 Grenville St., Toronto, Ont.

Apr. 28-30—Arizona Section, at Pioneer Hotel, Tucson. Secretary, A. D. Cox Jr., Secy. & Comptroller, Arizona Water Co., Box 5347, Phoenix.

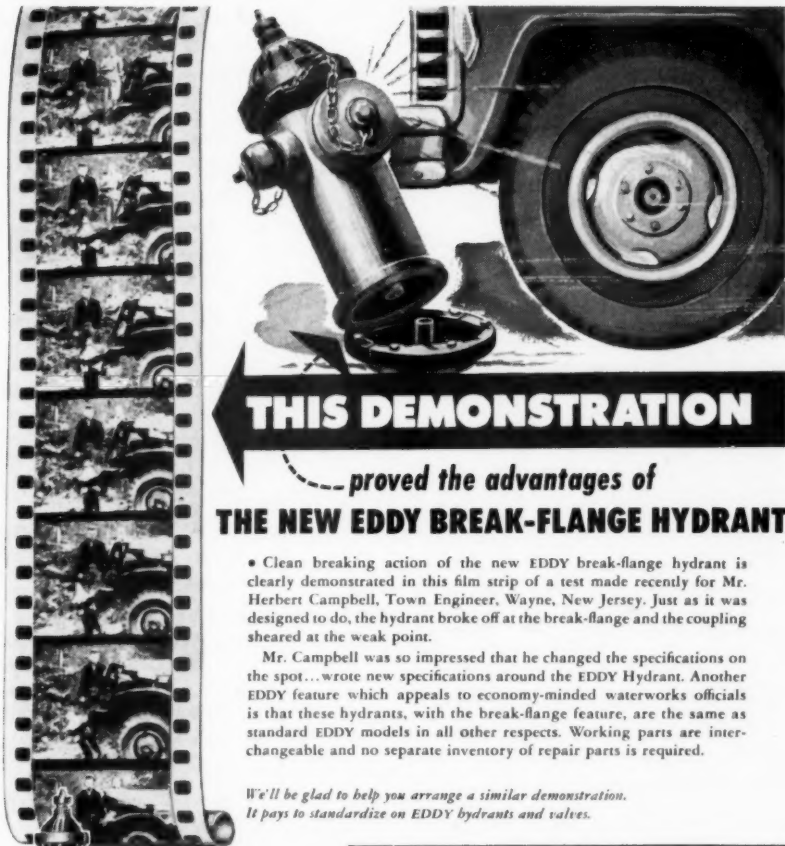
Apr. 28-30—Montana Section, at Northern Hotel, Billings. Secretary, A. W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

May 4-6—Pacific Northwest Section, at Benson Hotel, Portland, Ore. Secretary, F. D. Jones, W. 2108 Maxwell Ave., Spokane 11, Wash.

Jun. 2—New Jersey Section, at Riverton Country Club, Riverton. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Jun. 14-17—Pennsylvania Section, at Hilton Hotel, Pittsburgh. Secretary, L. S. Morgan, 413 First National Bank Bldg., Greensburg.

(Continued on page 8)



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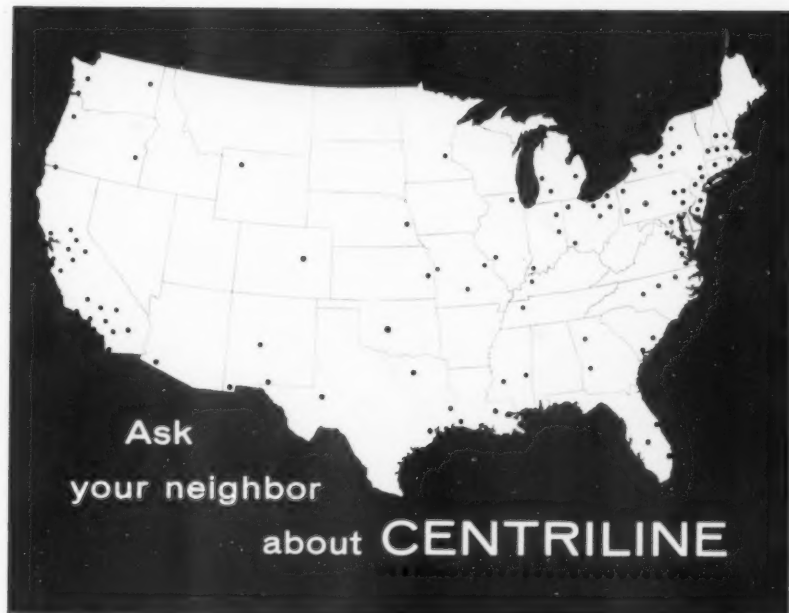
WATERFORD NEW YORK

Coming Meetings*(Continued from page 6)***Fall 1960**

- Sep. 7-9—South Dakota Sec., Watertown.
- Sep. 12-14—Kentucky-Tennessee Sec., Knoxville, Tenn.
- Sep. 14-16—Virginia Sec., Virginia Beach.
- Sep. 14-16—New York Sec., Whiteface.
- Sep. 21-23—Michigan Sec., Traverse City.
- Sep. 21-23—North Central Sec., Sioux Falls, S.D.
- Sep. 25-27—Missouri Sec., Jefferson City.
- Sep. 28-30—Wisconsin Sec., Madison.
- Oct. 9-12—Alabama-Mississippi Sec., Birmingham, Ala.
- Oct. 16-19—Southwest Sec., Galveston, Tex.
- Oct. 19-21—Iowa Sec., Des Moines.
- Oct. 19-21—Chesapeake Sec., Washington, D.C.
- Oct. 20-22—New Jersey Sec., Atlantic City.
- Oct. 24-27—Rocky Mountain Sec., Colorado Springs, Colo.
- Oct. 25-27—California Sec., Long Beach.
- Oct. 26-28—Ohio Sec., Columbus.
- Nov. 9-11—North Carolina Sec., Winston-Salem.
- Nov. 13-16—Florida Sec., Fort Lauderdale.
- Apr. 27-29—Conference on Algae and Metropolitan Wastes, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: A. F. Bartsch, Asst. Chief for Special Technical Services, Water Supply & Water Pollution Research, 4676 Columbia Pkwy., Cincinnati 26, Ohio.
- May 9-13—2nd Southwestern Metal Exposition & Congress, American Society for Metals, with other technical groups, State Fair Park & Sheraton Hotel, Dallas, Tex. Write: Allan Ray Putnam, Managing Director, Metals Park, Novelty, Ohio.
- Jun. 1-3—5th Appalachian Underground Corrosion Short Course, West Virginia University, Morgantown, W.Va. Write: John H. Alm, Rm. 605, 2 Gateway Center, Pittsburgh 22, Pa.
- Jun. 8-11—National Society of Professional Engineers, Statler Hotel, Boston, Mass.
- Jun. 20-Jul. 1—Course on "Aquatic Biology for Engineers," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).
- Jun. 20-24—Summer general meeting, AIEE, Atlantic City, N.J.
- Jun. 26-Jul. 1—ASTM, Chalfonte-Haddon Hall, Atlantic City, N.J.
- Aug. 23-25—Symposium on water quality data collection and utilization, R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Director, 4676 Columbia Pkwy., Cincinnati 26, Ohio.
- Sep. 18-22—NEWWA, Queen Elizabeth Hotel, Montreal, Que.
- Oct. 2-6—WPCF, Convention Hall, Philadelphia, Pa.
- Nov. 27-Dec. 2—Annual meeting, ASME, Statler Hilton Hotel, New York, N.Y.

OTHER ORGANIZATIONS

- Apr. 20-22—3rd Conference on Biological Waste Treatment, Manhattan College, New York, N.Y. Write: W. Wesley Eckenfelder, Assoc. Prof. of Civ. Eng., Manhattan College, New York 71, N.Y.



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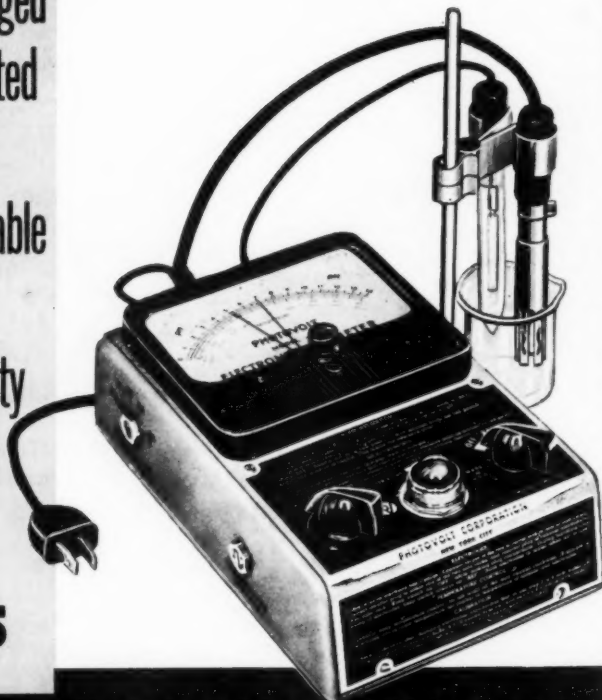
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PLASTIC PIPE AD WITH NO PICTURE?

Why no picture:

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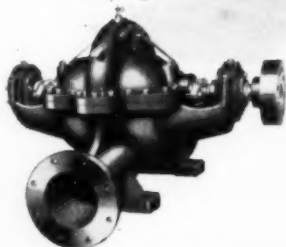
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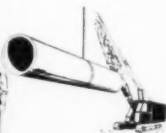
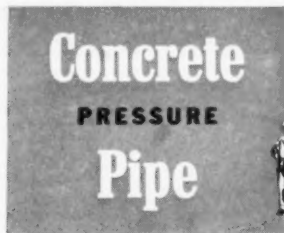
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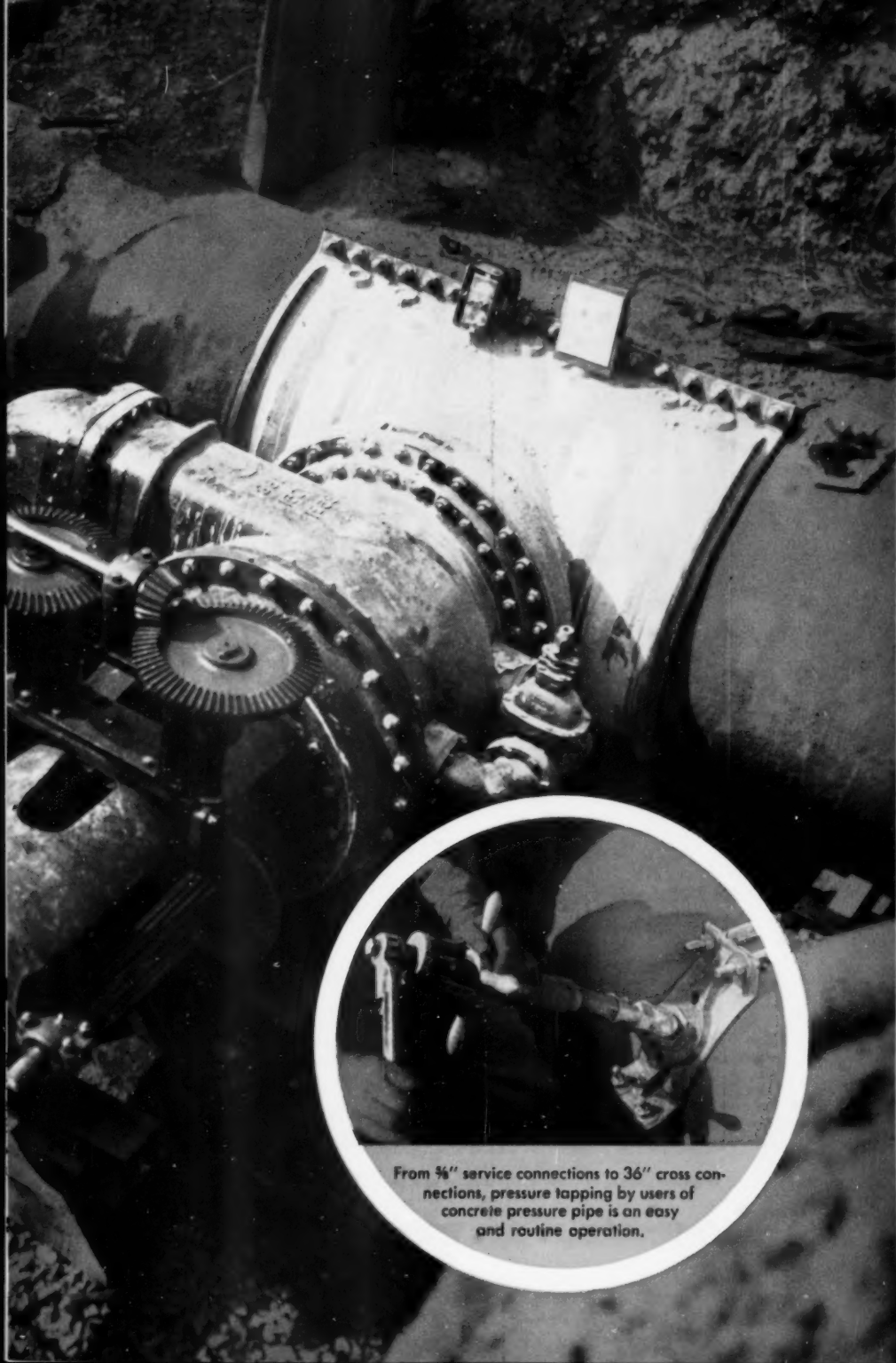
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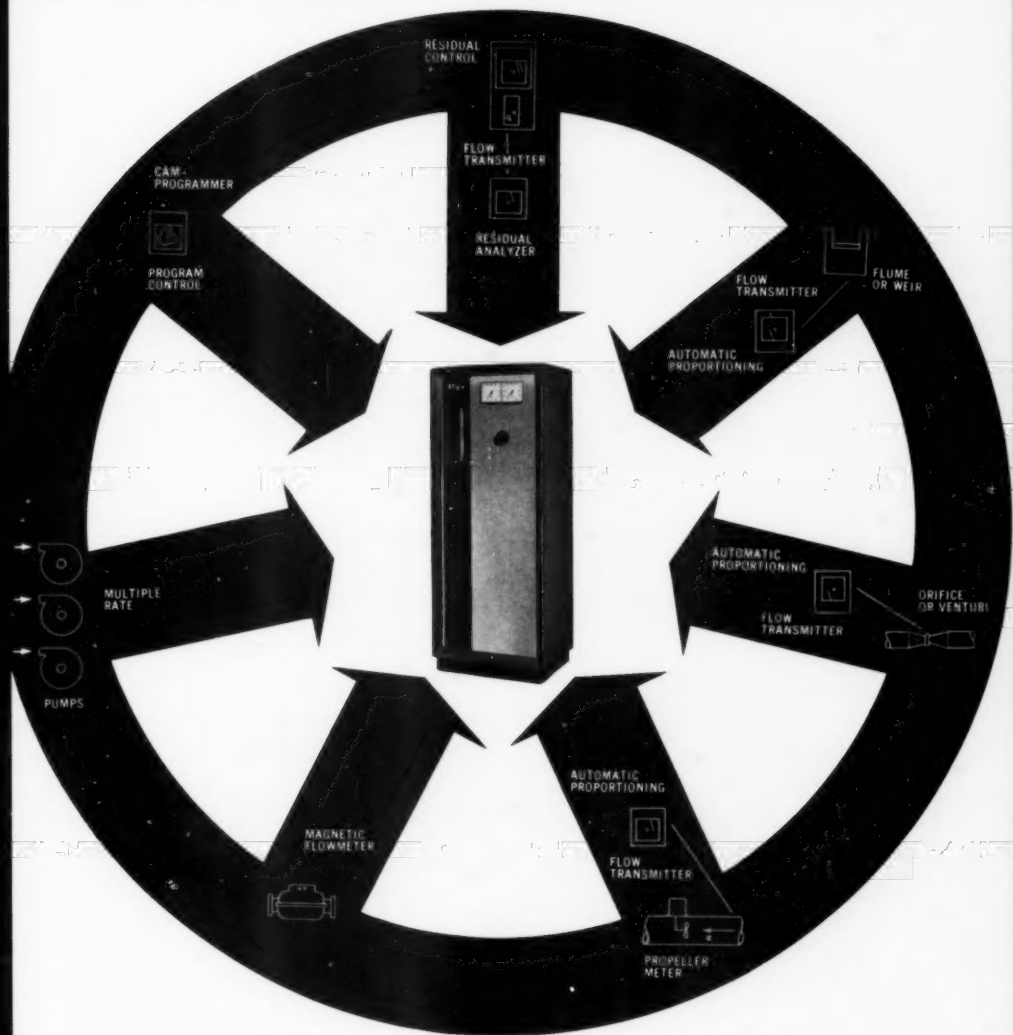
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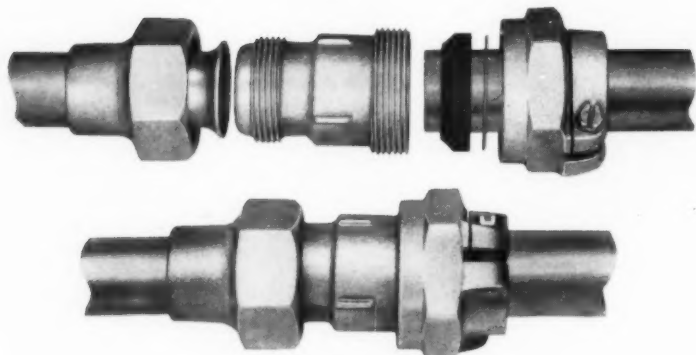
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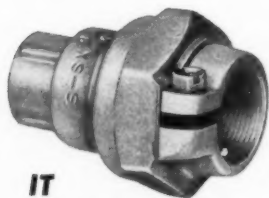
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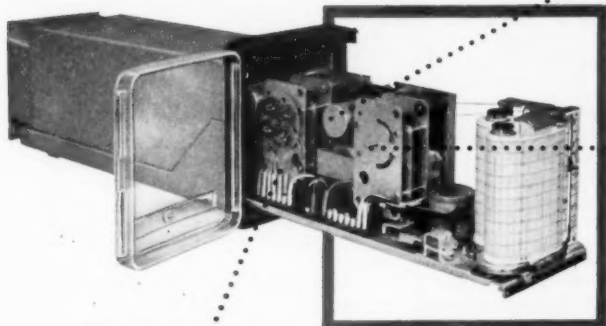
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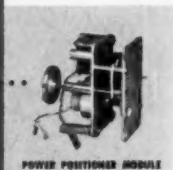
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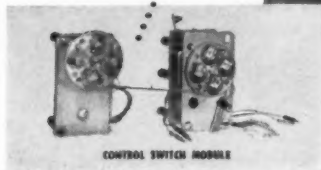
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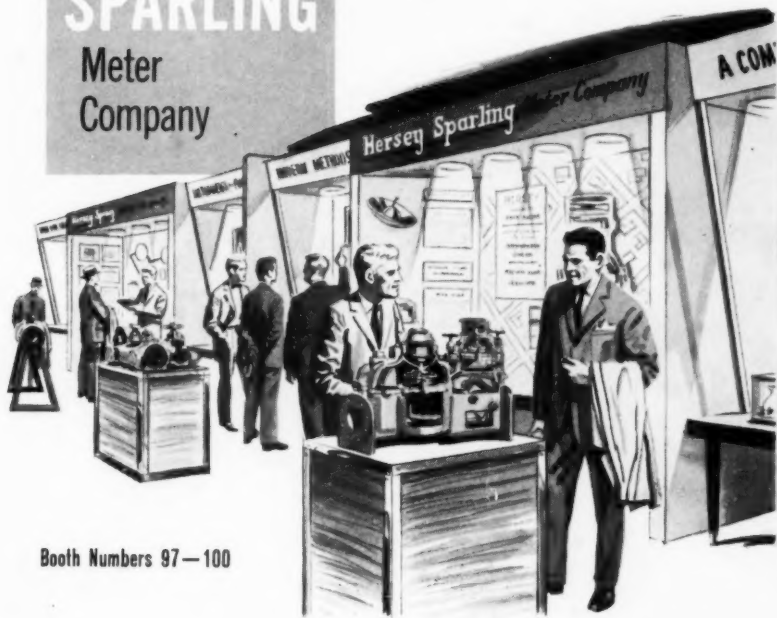
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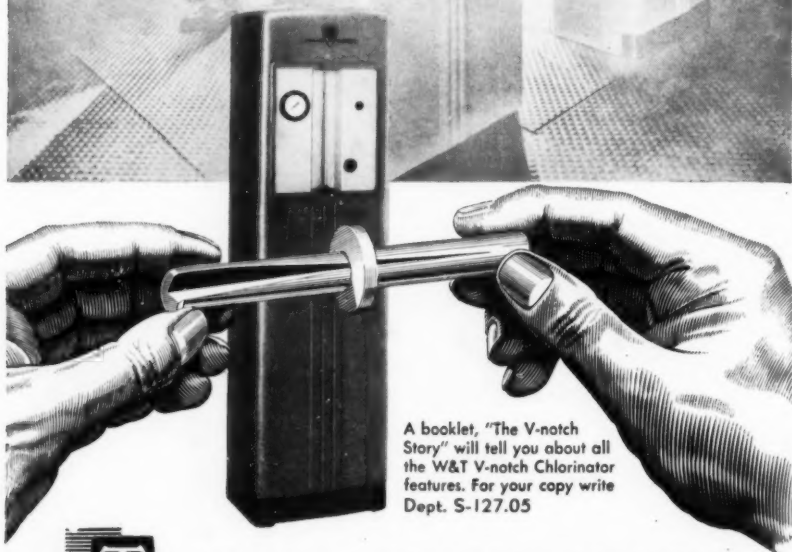
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AMERICAN WATER WORKS ASSOCIATION

VOL. 52 • APRIL 1960 • NO. 4

Municipal Fire Protection Surveys as Indicators of Water System Status

Kenneth J. Carl

A paper presented on Oct. 19, 1959, at the joint meeting of the Alabama-Mississippi and Southwest sections, New Orleans, La., by Kenneth J. Carl, Director of Munic. Surveys and Asst. Chief Engr., National Board of Fire Underwriters, New York, N.Y.

DURING 1958, AWWA inaugurated a Water Utility Advancement Program to assist water utilities in obtaining much needed improvements. The need for such a program was based on the fact that many systems were not meeting the needs of the communities that they serve. Water systems are generally considered to have two basic responsibilities: (1) to provide sufficient water to meet the demands of consumers and (2) to provide sufficient water for fighting fires. Because the water needed to fight fire must be available in addition to that used by consumers, it generally follows that a system that provides good fire protection can be depended on to meet the demands of its consumers as well.

NBFU Surveys

Since 1889, NBFU has been conducting municipal fire protection sur-

veys of large cities in the United States. The comprehensive type of survey made today was started in 1904 as a result of the Baltimore conflagration. One of the major factors considered in NBFU survey work is the water supply. A thorough analysis of the water system of each city is made, and the various features are compared with the standards contained in the NBFU "Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions." This schedule, first published in 1916, has been revised from time to time to keep up with modern developments; the latest edition was issued in 1956.

A review of the reports made on a given city over the years reveals many interesting facts concerning the growth and development of its water system. A comparison of the results of the

latest survey with those of the previous survey provides the information necessary to determine if a system: (1) has improved, (2) is just holding its own, or (3) has retrogressed in the intervening period. Because of the current interest in water utility advancement, a study was made to determine the number of systems in a representative group that would fall into each of these groups.

In the past 2½ years, surveys have been made in 89 cities that had previously been surveyed by NBFU. In comparing the recent evaluation of the water supply with that at the time of the previous survey, it was found that 42 (47 per cent) had improved and 11 (12 per cent) had held their own, but that 36 (41 per cent) had retrogressed. It should prove helpful to all who are interested in improving water systems to study a number of cities in each of the three categories and to find out some of the factors that contributed to the supply status in each instance.

In NBFU studies of water systems, the various factors that are considered fall into either of two groups; one involving adequacy, the other reliability. Under *adequacy*, the ability of the system to meet consumption and fire-flow demands under normal conditions is evaluated; under *reliability*, the ability to meet these demands under certain emergency or unusual conditions is considered.

Adequacy of Systems

A city surveyed in 1948 had a population of 62,000, with an average consumption of 5.5 mgd and a maximum consumption of 10.5 mgd. The required fire flow was 7,000 gpm, or approximately 10 mgd. In order to be considered adequate, a system

should be capable of delivering the required fire flow for a 10-hr period, with consumption at the maximum daily rate. In this instance, the required delivery rate would be 10.5 mgd plus 10 mgd, or a total of 20.5 mgd. In order to supply fire department pumpers effectively, the fire flow should be available with a residual pressure of 20 psi in the mains. This residual pressure is needed in order to overcome not only the friction losses in the hydrant branch, hydrant, and various pipe fittings between the main and hydrant outlet, but also in the suction hose, couplings, and various fittings that may be used by the fire department on the suction side of the pump. The fire-flow tests made during the survey showed that only 4,200 gpm would be available with consumption at the maximum daily rate, indicating that the system was inadequate.

In 1957, another survey was made in this city, which had increased in population to 89,000, with corresponding increases in average and maximum consumption to 13.0 mgd and 26.0 mgd, respectively. It is interesting to note that the maximum consumption rate of 26 mgd now far exceeded the 20.5-mgd rate needed for maximum daily consumption and fire flow in 1948. The city had made extensive improvements, most of which were needed to keep up with the increasing consumption, but which also provided better fire protection and some reserve for the future. The improvement program included the further development of the source of supply, the addition of filters and pumps, the strengthening of the distribution system, and the addition of elevated storage facilities. Owing to municipal growth, the fire-flow requirement had increased to 8,000 gpm, or 11.5 mgd, making the total required

delivery 26.0 mgd plus 11.5 mgd, or 37.5 mgd. When fire-flow tests were run, it was found that the required fire flow could be delivered with consumption at the maximum daily rate, indicating that the system was adequate. It should be pointed out that although the prime purpose of this city was to improve the adequacy of its supply, the overall improvements made also considerably improved the reliability of the system.

Reliability of Systems

Another city was surveyed in 1955. The population was 30,000 and the average consumption rate was 3.0 mgd, with a maximum of 6.0 mgd. The required fire flow was 5,500 gpm, or 7.9 mgd. There were only four wells supplying the system, each well equipped with a deep-well pump. The standard used to evaluate the reliability of pumping capacity requires that, with the two most important pumps out of service, the system be capable of delivering the required fire flow for 10 hr at any time during a 5-day period with consumption at the maximum daily rate. In the city under discussion, the remaining capacity with the two most important well pumps out of service was only 5.0 mgd, which was less than the maximum daily consumption rate of 6.0 mgd. Although there was approximately 1 mil gal of storage available, the system fell far short of meeting the requirements.

In 1957, the population of the city had increased to 33,000; the average daily consumption rate, to 3.5 mgd; and the maximum daily consumption rate, to 7.5 mgd. The city, however, had meanwhile installed three additional wells, with a capacity of 5 mgd each, as well as a 1-mil gal elevated tank. With the two most important

well pumps out of service, the remaining capacity was now 18 mgd, which could meet the increased maximum consumption rate of 7.5 mgd plus the fire flow of 7.9 mgd, without the use of storage facilities.

Another feature of reliability also can be illustrated by improvements made in this city. The four high-lift pumps are all electrically driven, three being in one station and the fourth in another station remote from the first. In 1955, each station was supplied with power over a single line. In the small station with a single pump of 2.85-mgd capacity, an interruption of power would not have been serious, because the three other pumps were available. With the larger station, however, a break in the single power circuit could have resulted in the availability of only 2.85 mgd plus a small supply from elevated storage to meet the fire flow and maximum daily consumption demands. The NBFU standard that covers power supply states that with any power circuit supplying pumping equipment out of service, the facilities remaining in service should be capable of supplying the fire flow for 10 hr at any time during a period of 2 days with consumption at the maximum daily rate. It is quite apparent that the pumping capacity of 2.85 mgd remaining in this instance was seriously inadequate, inasmuch as it was far less than the maximum daily consumption rate. In 1957, however, it was found that a duplicate power line had been provided for the larger station, so that an interruption in any one power line would not be serious.

On the subject of power supply, it would be well to mention a very important point that is frequently overlooked. In the attempt to provide reliable power supplies, duplicate lines

are very often run to a switching point on the station grounds or to the transformers serving the station, with a single line continuing to the bus bar serving the pumps. With this arrangement, any damage to the single line or bus bar may necessitate a shutdown of the station. Duplicate lines should be run to the bus bar, and the bus bar so sectionalized that a minimum of pumping equipment will be put out of service by any accident or repair. It is possible to sectionalize a bus bar supplied by two lines, so that not more than one pump can be put out of service by damage to any section. In order to provide full reliability with respect to power supply, facilities should be arranged so that a failure, repair, or replacement of a transformer, high-tension switch, control unit, or other power device, as well as the failure of a circuit, will not prevent the system from delivering the required fire flow for 10 hr during a period of 2 days with consumption at the maximum daily rate.

Improvements in Distribution

The improvements in the cities previously discussed have dealt, to a large extent, with supply features. A city in which the improvements of greatest importance were made in the distribution system merits discussion. In 1955, a survey was made in a city with a population of 40,000, having an average consumption of 6.5 mgd and a maximum consumption of 12.0 mgd. Fire-flow tests indicated that the required 6,000 gpm could be delivered in the principal business district with consumption at the maximum daily rate. The outstanding weakness of this system was the wide hydrant spacing in residential areas. In many sections, this was the result of the practice of

installing a gridiron of 2-in. pipe, supplied by widely spaced 6- and 8-in. mains. The hydrants were installed on the 6- or 8-in. mains and hence were too widely spaced for proper protection. Recognizing the inadequacies of a distribution system of this type, the city adopted a policy of installing no new mains smaller than 6-in. A program was also started to replace the 2-in. pipe with mains of proper size, so that adequate domestic service and fire protection could be provided. In 1959, another survey was made. During the time between surveys, the population had increased to 42,000. Also since the previous survey, 53 mi of 2-in. pipe had been replaced with larger mains providing a much improved gridiron, and the number of hydrants in service had doubled from 600 to 1,200, greatly improving the fire protection.

Retrogressive Systems

The cities discussed so far are those that have shown improvement. There are other cities in which the water supplies have retrogressed. A city surveyed a number of years ago had an average consumption of 6.0 mgd and a maximum consumption of 8.0 mgd. The required fire flow was 7,000 gpm. Fire-flow tests showed the system to be capable of meeting the maximum daily consumption rate plus the fire flow, and the system was generally reliable. On a recent survey, the population was found to be about the same as previously, but average consumption had increased to 8.0 mgd and maximum consumption to 12.5 mgd. When fire-flow tests were run, it was found that only 5,800 gpm was available with consumption at the maximum daily rate. Although the source of supply had been further developed since the

previous survey, so that more water would be available during dry periods, the mains of the distribution system had decreased in carrying capacity as a result of tuberculation, and no major distribution improvements had been made. A new line, proposed from the source to the distribution system, should greatly improve the present situation, but even with this improvement the system will not be as effective as it was in former years. This is a good illustration of inadequate planning, for the plan did not take into account all phases of the system. In other words, there was no overall plan either to keep up with the increasing demands or to take care of future needs.

In another city, a survey made some years ago showed the population to be 72,000 and the average and maximum consumptions 6.0 mgd and 9.0 mgd, respectively. The system was capable, at that time, of meeting the fire-flow requirement with consumption at the maximum daily rate, and had no difficulty in meeting the demands placed on the system during dry periods. During a recent survey, it was found that the population had reached 85,000, and that average consumption had increased to 9.0 mgd, with a maximum rate of 16.5 mgd. The filter capacity was limited to 15 mgd, making it necessary to use a number of emergency supplies of small capacity during periods of high consumption. These emergency supplies were barely adequate to meet the consumption demands, so that it was necessary to restrict water use at various times during the summer months. This example illustrates an attempt by a municipality to meet its increasing demands by piecemeal additions of small emergency supplies. It shows a lack of appreciation on the part of the city of its

responsibility to formulate well in advance the improvements needed to supply consumption demands, which eventually almost doubled. As is usually the case when a city finds itself in a serious situation, plans are now being prepared for an additional supply and increased filter capacity, plans that should have been made years ago.

A survey of a city of 45,000 people showed average and maximum consumption values of 5.0 mgd and 7.0 mgd, respectively. The system at that time was limited by filter capacity and storage, so that it could deliver only 5,700 of the 6,500 gpm required for fire flow with consumption at the maximum daily rate. In a recent survey, it was found that the population had grown to 60,000, with increases in the average and maximum consumptions to 9.5 mgd and 13.5 mgd, respectively. In order to meet the greater demand for water, a new source of supply had been developed and the old filter plant and pump station replaced by new facilities. Fire-flow tests indicated that with the new facilities the required fire flow could be delivered with consumption at the maximum daily rate. An analysis of the new supply works, however, revealed that several important features of reliability had been neglected. In fact, from a reliability standpoint alone, the arrangement of the former works was considered better. The old pump station was supplied with electric power by two circuits, but the new station relies on a single circuit. Because of the possibility that the single power line can go out of service, one of the pumps is driven by an internal combustion engine. This is one method frequently used to offset the unreliability of a single power line, but in this instance the capacity of the pump so equipped is too small, being less than

the maximum daily consumption rate. If pumps driven by internal combustion engines or other types of prime movers are installed in stations in which the pumps are normally electrically operated, sufficient capacity should be installed to meet the previously mentioned standard on failures in electrical circuits or equipment.

Another feature of unreliability in this system is the dependence on single pipelines at several places in the supply works. The standard used to evaluate the reliability of a system with respect to supply lines requires that with any line out of service, the remaining facilities (including additional supply lines, storage, additional sources, and emergency supplies) should be able to deliver the required fire flow for 10 hr at any time during a period of 5 days with consumption at the maximum daily rate. If a break occurs in any of the single lines that form a part of the supply works of the system, the only remaining source of water is the storage on the system, which is less than half the average daily consumption. The former supply facilities were arranged so that the effect of a single line out of service was not serious. It seems ironic that when the new supply facilities were planned, the reliable features included in the design of the old facilities were omitted.

Static Systems

The cities showing no change in NBFU evaluations fall within two groups: those that have adequate supplies and those that do not.

A city previously surveyed had a population of 59,000, with an average consumption of 7.0 mgd and a maximum consumption of 11.0 mgd. The required fire flow of 7,000 gpm was available with consumption at the

maximum daily rate, and the system was fairly reliable. On a recent survey, it was found that, although the population had increased to only 60,000 within the city, the system was supplying about 40,000 additional people in areas outside the city which had developed since the previous survey. The average consumption had increased to 17.0 mgd and the maximum to 25.5 mgd. Tests showed that the fire-flow requirement could be met with consumption at the increased maximum daily rate. In order to keep up with the demands imposed on it by the growing community it serves, the utility had enlarged its impounding reservoir, installed additional pumps, constructed a new supply line from the supply facilities to the distribution system, and improved and extended the arterial system. In spite of all these improvements, the system had just about kept pace with its demands. In fact, the evaluation made as a result of the survey showed that the overall fire protection provided by the system was about the same as it was at the time of the previous survey.

The same situation exists in many growing cities. When NBFU engineers meet with city officials in a conference that takes place before a survey is started, the important installations made since the previous survey are usually outlined by the head of the water department. In most instances, the city officials believe that the effect of these installations is an overall improvement in the water supply. Frequently, however, the improvements have been offset by increases in consumption and area served, so that the net effect is that the city is just about holding its own.

Another city surveyed in 1947 had an average consumption of 1.8 mgd

and a maximum consumption of 3.7 mgd. The required fire flow was 6,000 gpm, but owing to limitations in the supply works, only 2,200 gpm was available with consumption at the maximum daily rate. In fact, even with consumption at the average daily rate, only 3,500 gpm was available. This system was, of course, seriously inadequate, and, although recommendations were made for improvement, very little attention was given to them by city officials. A survey in 1957 showed that average consumption had increased to 2.3 mgd, and maximum consumption to 4.1 mgd. The only significant change made since the previous survey was an increase in well capacity from 4.2 mgd to 4.6 mgd. It is quite obvious that no improvement in this inadequate system could have been expected as a result of this change, because the increase in well capacity (0.4 mgd) was just equal to the increase in maximum daily consumption. Although, from the standpoint of NBFU evaluations, the city might be considered as holding its own, it certainly is failing to meet the needs of its citizens.

Supply of Suburbs

Most cities in the United States are growing, and many cities are expanding to establish new city limits encompassing much previously undeveloped area. As such areas build up, it is necessary to provide them with water for domestic use and for fire fighting. Frequently, an attempt is made to supply these outlying areas merely by extending 6- or 8-in. mains from the existing gridiron. In many instances, the existing gridiron may be inadequate or just barely adequate to meet the existing demands, and the additional load imposed by the extensions makes the overall condition worse. Before extensions

are made, flow tests on the existing system should be conducted to determine the amounts of water that can be delivered in the vicinity of the newly developed areas. A decision can then be made as to the best method of supplying those areas. It will be found that very often an arterial or large feeder main will have to be installed for such areas and that this main will have to extend back into the existing distribution system to a point where it can be adequately supplied by arteries with excess capacity. In some instances, it may be necessary to go back all the way to the supply facilities. When such procedures are followed, these mains can be used not only to provide a good supply for the new areas, but also to strengthen the existing distribution system by connections to it at close intervals.

Unfortunately, such procedures have not always been followed, and the supply available for fire fighting in many outlying areas is poor, especially if it is necessary to provide fire protection for one of the large modern shopping centers. These new areas offer a challenge to every water utility engineer, and the provision of adequate supplies for them should be a very important part of any water utility advancement program.

Another problem in outlying areas is that of hydrant distribution. The street pattern in most new areas is much different from the checkerboard layout that exists in the older sections of cities. In many of these new areas, hydrants are being spaced much too far apart. A rule-of-thumb suggestion for residential areas is that a hydrant be installed at each street intersection and that intermediate hydrants be provided where necessary so that the distance between hydrants will not be

more than 500 ft. This procedure will generally provide adequate protection in most residential areas. In shopping centers, however, additional hydrants will be necessary to provide the fire flow required to fight fires in the large undivided fire areas characteristic of the buildings in these centers. In several places, large shopping centers have been erected with only one hydrant provided for protection where at least six or more hydrants are actually needed. No fire department can be expected to perform satisfactorily with such a deficiency in hydrants. In many municipalities, a review of the protection being provided for shopping centers should be made and appropriate action taken by responsible officials to correct any instances in which the number of hydrants or the water supply is inadequate.

Conclusion

Since 1904, when NBFU began its comprehensive municipal survey work,

reports have been issued to city officials containing analyses of their water systems and conclusions and recommendations for improvement. In this 56-year period, many of the systems have grown tremendously and have made great progress. On the whole, the water supply industry has definitely moved ahead. It is also recognized, however, that a large percentage of the systems either are static or have retrogressed.

It is quite evident that retrogressive systems usually are the result of little or no planning; static systems, the result of some, but not enough planning; and progressive systems, the result of adequate planning well into the future. One of the objectives of the AWWA Water Utility Advancement Program is to encourage planning that recognizes not only present but also future needs. NBFU will do everything possible to help the water supply industry meet the challenge of this program.



Handling Customer Complaints in the Philadelphia Water Department

—Carl W. Frey—

A paper presented on Jun. 3, 1959, at the Pennsylvania Section Meeting, Wernersville, Pa., by Carl W. Frey (deceased), formerly Chief, Customer Service Sec., Philadelphia Water Dept., Philadelphia, Pa.

REGARDLESS of how earnestly a water department strives to provide an ample supply of good quality water under the right pressure at a fair price, it is bound to get complaints from some of its customers. The development of good will between department and customer depends, to a large extent, on the manner in which these complaints are handled.

Customer Relations

A water department can use two basic approaches to customer relations. One is the deliberate effort to create good will. The other is a domineering attitude, which implies that the department, because it has a monopoly power, does not have to take customer complaints seriously. There can be no doubt as to which approach promotes better relationships.

The coercive, domineering approach breeds enmity, and is, or should be, a thing of the past. No efficiently operated utility today recognizes coercion as a tool in customer relations. In dealing with complaints, it is just as important to do away with enmity as it is to win an argument. The appeal to good will, on the other hand, is persuasive. Properly presented, it wins the assent of the customer by changing his way of thinking, so that he understands and genuinely wishes to accept a situation he previously rejected.

Those in utility management have probably found that a complaining customer can be made to understand the reasons for, and be patient during, periods of inconvenience. Recently, a customer telephoned the Philadelphia water department to complain that his entire street was out of water. By that time, phones on a number of desks in the customer service section began ringing. Customer service was advised by the distribution division that there was a break in a 48-in. main located in a valley. Within the next 20 min, it was almost possible to trace the rate at which the break was emptying the system by the location of the complainants. Customer service was also advised that the main would be out of service for about 4 hr, which included the dinner hour. The calls of complainants were answered as rapidly as possible, and each person who telephoned was advised of the location of the break, the period of time that the water would be off, and what was being done to repair the main. Within the next 3 hr, about 200 of these calls were answered, but none of the complainants was angry after being advised of the situation.

Those in customer service stand by the principle that no one ever wins an argument with a customer. They believe that it takes a special kind of person to handle customer complaints

satisfactorily, and they know that it requires constant supervision to make certain that when they make a statement it will not be contradicted by another employee.

One approach found to be particularly effective in handling irate customers is to let them talk themselves out. One can tell when this point has been reached, for then the complainant begins to repeat himself. When this happens, the customer service man starts to get in a word. Soon he is doing most of the talking and explaining. If the complainant is at all rational, he can be made to understand a situation. It is not a matter of out-talking him, but of convincing him that the department is doing its best to set things right.

Philadelphia Water Department

The Philadelphia water department consists of four main divisions: water operations, sewage operations, engineering, and administration. Water operations is responsible for pumping both raw and filtered water, filtering and chemically treating the water, and maintaining 2,900 mi of distribution mains and 24,000 fire hydrants. Sewage operations is responsible for collecting and treating the sewage of nearly all the department's water customers, as well as the sewage of a number of surrounding communities; disposing of the treated sludge; and maintaining nearly 2,400 mi of sewers, including manholes and inlets. The engineering branch is responsible for the design and construction of all water and sewage facilities. The department also has a meter repair shop under the supervision of the administration division; the shop services and maintains more than 500,000 water meters. Servicing and maintaining these meters

is done without direct charge to the customer. The entire city is metered, except for less than 0.4 per cent of customer lines.

With the establishment of a water department under the new city charter in 1953, the water commissioner saw the need for a unit in the department to handle customer complaints, in addition to performing other functions in dealing with customers. The customer service section was established and assigned to water operations, because it was believed that the greatest number of customer contacts might arise there. The section, however, responds to complaints concerned with activities of any departmental division. To start the section's activity, a field force and office force of an existing unit were assigned to the section. This existing force was previously an enforcement unit rather than a service unit. That background came in handy in its new function, for this section was still responsible for enforcing the rules and regulations of the department.

Areas of Responsibility

According to the regulations of the Philadelphia water department, the customer is responsible for the maintenance of his service line, if it is 2 in. in diameter or smaller, from the water main to and including his house piping, with the exception of the meter, which in Philadelphia is nearly always in the cellar. He is responsible for the construction and maintenance of a meter pit. He is obliged to purchase a water meter, at which time the department assumes ownership of the meter and the responsibility for its future maintenance. The customer is also responsible for the maintenance of his sewer lateral—from its connection to the department's sewer—to and including his

house drain. The department is responsible for maintenance of the sewers, manholes, and inlets.

The service line is laid by a registered master plumber, in accordance with the rules and regulations of the department and under the inspection of representatives of the customer service section. The department is responsible for the maintenance of the water distribution mains, fire hydrants, valves and valve boxes, and water services that are 3 in. in diameter or larger.

Customer Service Section

Although the customer service section is bound by departmental regulations and council ordinances in many of its activities, it favors the customer whenever such action is not a direct violation of the governing legislation. As an example, a particularly bad discolored-water condition existed in the premises of one residential customer. The residence is in an area of semidetached homes, and, aside from an occasional mild complaint from another resident, this house is the only one to receive badly discolored water. This is a real, not an imaginary, discolored-water condition. The mains have been flushed many times, but the customer complained again and again. There are three mains in the street: 8 in., 12 in., and 20 in. in diameter. The customer's service is attached to the 8-in. main.

Frequent visits were made to the premises, and the main was flushed frequently. The plumber who did work on the premises within the past 4 years was consulted. He removed iron pipe from the footway and replaced it with copper. He explained that the service from the main to the curb cock is lead and apparently in good condition, that all interior piping is copper, and that

he put in a monel metal hot-water tank about 3 years ago. It was evident that the fault did not lie with the customer. But still the reason for the discolored water was not apparent, inasmuch as there were a number of other customers using the same 8-in. main who received clear water. In trying to eliminate the unsatisfactory condition, the department excavated and disconnected the service from the 8-in. main and connected it to the 20-in. main. The water from this service is now clear. For the department, this operation was a radical procedure. A customer's service is never relocated except when the department relays a water main. But the operation is an example of the aim to satisfy a customer within the limits of departmental authority.

Every complaint to customer service about discolored water is investigated by a field representative. In many instances, the condition is obviously caused by the customer's corroded iron pipe, or by a corroded domestic hot-water tank. In these instances, the customer is advised to call a plumber. At other times, however, the fault may lie with the system. Then the distribution division is requested to flush the mains in the area. If at all possible, this is done that same night. Flushing of mains is done at night, after the needs for water have been lessened, in order that disturbances in the mains can subside and clear water be supplied the next day.

In some areas of the system, a periodic flushing schedule has been established to clean out the mains before complaints become necessary. When this schedule is adhered to, the number of complaints decreases. When the schedule is not followed, the water department is quickly made aware of it.

Short-supply complaints are handled similarly. A field representative visits the customer who complained. He also visits several other properties on the same street. If it appears that the short supply is in only one property, the premises are examined to determine the cause of the condition. If the short supply is in a number of properties, the distribution division is asked to look into the matter. The division checks into the conditions that same day, and makes corrections if at all possible. Quite often a street valve is found to be closed or only partly open. Although the department has a firm rule that only distribution division personnel operate valves in the system, occasionally a contractor laying a water main for the department will operate a valve and cause a reversal of flow in the main.

Basic Procedures

The customer service section, although assigned to water operations, responds to complaints concerned with activities of any of the divisions mentioned earlier. For purposes of routing, the section has divided the city into ten geographic districts. The districts are not equal in area, the sizes being determined by traffic conditions and incidence of activities. District boundaries are not inflexible; frequently field representatives are dispatched outside their district boundaries.

As a complaint is received on the phone by a complaint dispatcher, the pertinent information is entered on a complaint record, the time that the complaint is received is recorded, and the complaint is phoned to a radio dispatcher for relay to the regularly assigned field representative, if he is available to handle the assignment. If he is too busy, the assignment goes to another representative. If the field

representative finds the condition to be such that action must be taken by the water department, a call is made to the proper division in an attempt to relieve the condition that same day. If the complaint requires that corrective action be taken by the owner, a formal notice, known as a "leak notice," is left on the premises. This notice is a three-part form. The first part, as mentioned, is left on the premises, the second part is mailed to the owners, and the third part is placed in a tickler file for followup.

As mentioned earlier, the customer is required to maintain his service line if it is 2 in. in diameter or smaller. If, in the course of events, it is determined that the field representative served the leak notice in error, the department pays the plumber's bill—up to the point of renewing the service—pays for the permits, for labor in excavating, and for backfilling, if a new service has not been put in. The customer is not made a victim of the department's errors.

Any complaint received in the office of the customer service section prior to 4:00 PM is handled that day by section personnel. Any complaint received after 4:00 PM is handled by an emergency crew working for the distribution division. These emergency crews work every day of the year and very often give emergency relief until such time as a permanent correction is made. They are frequently called out at night in response to a complaint of water in the street, in a cellar, or in a house.

The meter shop also works after regular business hours and on weekends, for meter crews work overtime on emergency calls, investigating all complaints that sound urgent. And when an industrial customer cannot shut down his water supply during the

week so that a defective meter can be removed, the job is done on a Saturday, at no charge to the customer.

Billing Complaints

Reading of water meters, billing for water and sewer charges, and the collection of accounts are functions of a separate and distinct department of the city government, the department of collections. But any complaints about water bills, if directed to the water department, are investigated by customer service. Records of the department of collections pertaining to the complaint are studied. No direct action, however, can be taken by the water department, which forwards to the department of collections the findings and recommendations made by customer service.

Written replies to all mailed-in complaints concerning bills are prepared by customer service, even if only to advise the customer that his complaint was reviewed and forwarded to the department of collections. Inasmuch as many of these complaints require field inspections and office record inspections, several days may go by before an answer is ready for the complainant. Upon receipt of the complaint letter, however, it is acknowledged by postal card to advise the complainant that the matter is being investigated and that he will hear from the department when the investigation is completed.

The water department purchased two meter-testing devices to facilitate investigations of bill complaints. These devices have frequently proved that bills were correct. Recently, a large meat products processing plant complained about a high water bill. This plant uses a great deal of water in refrigeration, although the plant engineer

did not think so because the plant had a water recirculator. The engineer could not be convinced that the meter was correct, not even after a shop test. But when the testing device was set on the meter to check the readings, the engineer saw proof that the recirculator did not work. Although the water department is not responsible for billing, it believes that its money and time are well spent on billing complaints if customer relations are improved.

Personnel and Activities

The customer service section consists of 42 employees, of which 24 are field personnel, 3 are supervisors, and the other 15 are the clerical force. The field force is made up of 16 field representatives and 8 field inspectors. The entire field force is issued uniforms for summer and winter, at no cost to the employee. Each field man is also issued an identification card showing his signature and his photograph. As mentioned earlier, each field representative is assigned to a geographic district and provided with a passenger car equipped with a two-way radio. Thus, he is within constant reach of his supervisors.

Customer service handled more than 31,000 complaints and requests for information and service during 1958. More than 60,000 inspections were made and 2,000 written replies prepared during the same period.

Because other departmental sections besides customer service also receive complaints, the water department is studying the possibility of organizing a centralized customer service section to handle all complaints round the clock, 7 days a week. At the present time, the activities of the customer service section are limited to the usual working days.

Organization and Standards of the Oakland County Department of Public Works

—Harold K. Schone—

A paper presented on Sep. 24, 1959, at the Michigan Section Meeting, Saginaw, Mich., by Harold K. Schone, formerly Director of Public Works, Oakland County, Pontiac, Mich., now City Mgr., Arcadia, Calif.

THE organization of the Oakland County, Mich., Department of Public Works is now being completed, and the standards of the department are being perfected. Of course, the job of perfecting an organization that expects to serve the public faithfully can never really be complete, for better and more economical methods and materials must always be sought. The problems in Oakland County that existed prior to, and resulted in the need for, the organization of the county department of public works merit discussion.

Preorganization Problems

A multiplicity of governmental units existed in the county, particularly in the heavily populated southern portion. The population of the county in 1940 was 254,068; in 1950, 396,001; and now it has an estimated population of 685,000. The citizens reside in 22 cities, 17 villages, and 24 townships. All these units of government have varying degrees of authority and financial ability, to the extent that no great common ground exists for developing community facilities, which, for topographic and economic reasons, have no relationship to municipal boundaries.

For example, one area involved the sanitary sewer needs of parts of three

townships and three cities. In 1952, it was recognized that the proper solution to the problem of this area was to construct a gravity interceptor sewer that would connect to the city system of Detroit; the sewage would then be transported to the Detroit plant for treatment. Separate treatment plants would have been too costly and would have increased, rather than reduced, pollution in the area. Several attempts toward a solution were made, but nothing definite was accomplished until the passage of Act 233 of the Michigan Public Acts of 1955, which provided for the creation of authorities to handle such problems. These municipalities did, in 1956, adopt articles of incorporation for an authority to undertake the construction of interceptor sanitary sewer systems throughout the area, and plans were completed for a portion of the area. The project, however, like many others, fell by the wayside, because it was necessary to have a vote on the project in one of the townships, and the proposal was defeated.

Other sewer problems had arisen where water supply was either critical or nil, so that even if a solution to the sewer problem had been found, there was no agency to handle the problem of water supply on an area basis. Dur-

ing this same period, officials in Oakland County began to realize that they had disregarded the possibilities of areawide planning and development of basic facilities. This was attributed to:

1. A lack of proper planning that could result in acceptance and enforcement of an approved plan

2. A lack of a sense of obligation on the county or intercounty level to assume responsibility for working out area problems, primarily based on a fear of infringing on local home rule

3. A feeling on the part of small units of government that they might become dominated if their problems were to be solved on a higher level of government

4. A feeling on the part of some governmental units that they could solve their own problems without having to be concerned with the rest of the area

5. A lack of statutory authority to proceed with areawide planning.

The same apathy to county development has probably existed in most of Michigan.

Creation of County Department

In the latter part of 1955, numerous county and municipal officials, along with private citizens primarily engaged in building and real estate, met to discuss some method whereby intracity or township projects could be carried on without being hampered by the complicated existing drain laws. Also discussed were the ways that a water supply program could be handled. As a result of this meeting, the drain commissioner submitted a report to the drain committee of the Oakland County Board of Supervisors, recommending the creation of a department to handle sewers, drains, and water supply, with suggestions on its organization.

Consequently, the chairman of the board of supervisors appointed a study committee, which met on numerous occasions during the late summer and fall of 1956. These meetings resulted in the drafting of a bill that was submitted to the legislature in the 1957 session. The bill provided for the creation of a department of public works, on a two-thirds vote of the board of supervisors, in counties with more than 75,000 people. This department, on the approval of the board of supervisors, would have powers:

1. To acquire a water supply system within any one or more areas in the county and to improve, enlarge, extend, operate, and maintain such a system

2. To acquire a sewage disposal system within any one or more areas in the county and to improve, enlarge, extend, operate, and maintain such a system.

By definition, *acquire* means the acquisition by purchase, construction, or by any other method; *water supply system* means all plants, works, instrumentalities, and properties used or useful for obtaining a water supply, the treatment of water, or the distribution of water; *sewage disposal system* means all sanitary sewers, storm sewers, combined sanitary and storm sewers, plants, works, instrumentalities, and properties used or useful for the collection, treatment, or disposal of sewage (which includes storm water, sanitary sewage, and industrial wastes).

Financial Provisions

The bill provided for the following methods of financing:

1. The issuance of revenue bonds under the provisions of Act 94 of the Public Act of 1933, as amended

2. The issuance of bonds in anticipation of collection of amounts to become due under contracts whereby municipalities agree to pay certain sums toward the cost of acquisition, improvement, enlargement, or extension

3. The issuance of bonds in anticipation of the payments by special assessments made by the board of public works

4. Money loaned by the county, under agreements with municipalities, for the repayment of the debt.

Bonds to be issued under the act were to be authorized by an ordinance or resolution approved by the board of public works and adopted by the board of supervisors. The board of supervisors is authorized to pledge the full faith and credit of the county for the prompt payment of principal and interest on any bonds issued pursuant to the provisions of the act. Thus, departments like Oakland's have the advantage of financial flexibility, which permits the use of any of the above methods of financing, as well as any combinations, in a single project. This advantage does not exist under the statutes by which authorities, as well as road and drain commissions, operate. Because of the resultant flexibility in financing, Bay County, Mich., also created a county department of public works. In addition, officials from Oakland have met with committees from other Michigan counties—Kent, Washtenaw, and Wayne counties—which are seriously considering the creation of departments within their county governmental structures in order to solve their water and sewer problems on an area basis.

The Oakland bill was adopted in the 1957 session of the legislature and is now known as Act 185 of the Public Acts of 1957.

Organization of Department

The Oakland County Board of Supervisors, on Jun. 24, 1957, authorized the creation of the department of public works, pursuant to the act, and appointed the board of public works, which at that time consisted of five members. Now the board has seven members, six of whom are members of the board of supervisors. The seventh member is the drain commissioner, be-

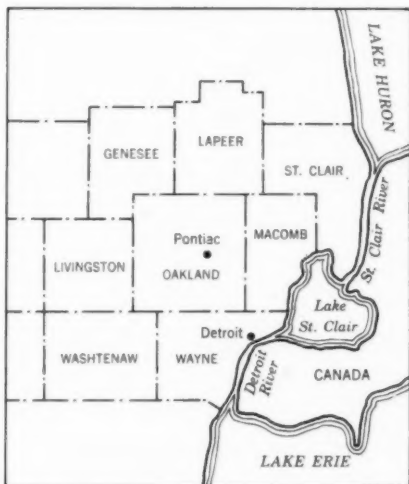


Fig. 1. Geographic Location of Oakland County

Shown are the Michigan counties surrounding Oakland, and the location of the large bodies of water nearby.

cause the act requires that in counties where there is a drain commissioner, he must be a member of the board of public works.

The board of public works met shortly thereafter and appointed a director of public works. On Aug. 16, 1957, the director submitted a report to the board on the feasibility of constructing two projects: the Evergreen

sewage disposal system, servicing all or parts of five cities, three villages, and two townships; and the Farmington sewage disposal system, servicing all or parts of two cities and two townships. After many months of litigation, including supreme court decisions, these two projects are now under construction and approximately 45 per cent complete, at a total cost of \$12,667,000.

The department has increased in 2 years from one director to a 66-member staff that includes a large number of field inspectors. The deputy director of public works has a long background of construction experience, with particular emphasis on the construction of sewer and water facilities. The department also has a chief engineer and two assistant chief engineers, both of whom have had considerable experience in water and sewer work. The superintendent of sewer and water supply is the former assistant manager of the Southeastern Oakland County Water Authority. Attempts have been made to select carefully all the employees of the department in order to assemble a highly qualified staff.

County Projects

During the past 2 years, the department has acquired, and is now operating and maintaining, and doing the billing and collecting for, about 29 separate water systems in the area, all using the ground source of supply. Four sewage treatment plants have also been acquired, and a \$660,000 sewer and treatment plant is under construction to serve the new Michigan State University of Oakland and about 3.5 sq mi adjacent to it. At the same time, a water system is being constructed.

Another major project is the planning of public facilities for about 200

sq mi of the Clinton River drainage basin, lying within Oakland County. This is being financed by a \$400,000 "planning advance" made available to the department by the federal government. Although the emphasis thus far has been on sanitary sewage disposal, the department realizes that needed with sewer systems are adequate water supply and distribution systems. Therefore, the department is interested in the efforts of the Southeastern Michigan Water Authority, comprised of Oakland and Macomb counties (Fig. 1), to bring in a supply of treated water from Lake Huron. The Oakland County Department of Public Works has never believed this to be practical, because water in the area must be supplied on a competitive basis with the water being distributed by the city of Detroit. This would be impossible with the small demand that would be made on the authority's supply system for the first 5 or 10 years of operation. These views have been made known publicly, and the department has advocated a single water system, headed by the Detroit water board, that would serve the Detroit metropolitan area.

In the past few months, the Detroit board of water commissioners has released its water development program for the Detroit metropolitan area. Although many questions have yet to be resolved, the Oakland department gives its support to this plan, with certain minor reservations. Many political and policy decisions must be made by officials other than those in the Oakland department. Since the release of the Detroit report, the department has submitted two reports to Oakland County officials, urging that immediate tentative approval be given to the plan and that the department of public works be au-

thorized to proceed immediately with a master plan of distribution systems in the areas of the county where water is needed immediately, keeping in mind at all times the future water needs of the entire county.

It is strongly believed that the department will and must be the main authority over the water supply, insofar as it affects Oakland County. This, of course, excludes the area of the county now being served by the Detroit system, as well as the city of Pontiac, for both are capable of meeting their own needs when the supply is made available by Detroit.

Standard Specifications

One of the major problems that the department has encountered in its water system program is the variance in materials and construction of existing systems. In an attempt to standardize systems, the department has developed standard specifications that must be followed in all areas in which the department operates. The purpose of the specifications is to provide for good public facilities by establishing minimum requirements for design, construction, testing, and materials, with the end product being reliable, economical facilities in keeping with accepted health standards.

There may be conditions for which there are no specifications. For such instances, a course of action must be prescribed by the consulting engineer and jurisdictional governmental unit. It should be remembered that these specifications indicate the minimum requirements, not necessarily the most desirable requirements. Therefore, wherever practicable, designs, methods of construction, methods of testing, and choice of materials should be employed to provide the greatest functional effi-

ciency, structural security, and sanitary protection for the proposed public project. The specifications are not intended to violate or subjugate any of the requirements of the Michigan health department, which derives its right of control through Act 219 of the Public Acts of 1949.

The specifications have been approved by the Oakland County Board

TABLE 1
*Appropriations and Expenditures for
Department of Public Works
and Drain Office*

Agency	General Fund Appropriation \$	General Fund Expenditures \$	Total Expenditures \$
	1957*		
Dept. of public works	50,000	8,026	39,225
Drain office	70,634	70,350	999,513
	1958		
Dept. of public works	100,150	7,526	252,520
Drain office	121,735	120,493	1,612,737
	1959†		
Dept. of public works	23,400	8,372	1,095,347
Drain office	118,455	59,706	572,964
	1960		
Dept. of public works	10,250		
Drain office	106,650		

* Appropriation and expenditures for the department of public works pertain to 5 months of the year.

† Seven months of the year.

of Public Works. Recognizing that water systems will be constructed in areas over which it has no control, the Oakland department has strongly recommended to the units of government that they adopt the specifications. Of necessity, the regulations or minimum standards of the Michigan health department, insofar as they affect water

systems, must be applicable statewide, and can only be applied to matters concerning the public health. The class of pipe, hydrant installation, and other matters are not controlled therein.

The department of public works is also developing minimum standards for sewer construction and is hopeful that it will be able to obtain statutory authority from the legislature, which would give the county the right to enforce the minimum standards throughout the county, whether or not there is any control by the department. This may appear to be a dictatorial and arbitrary position, but the department must face the problem of future public water supply and feels that the best interests of the citizens will be served if the systems installed at this time are built so that they can properly be connected to the eventual metropolitan system. It is also recognized that eventually all the present and future systems that utilize ground water as a source of supply will be connected to a public supply, such as that of the Detroit metropolitan system. They will also be interconnected for purposes of insuring an adequate and continuous supply of water. It is, therefore, imperative that minimum standards be applicable throughout the area proposed to be encompassed in the system.

Appropriations and Expenditures

Because the department of public works is not required to account to the board of supervisors for expenditures outside of budget appropriations, it could become a self-contained entity apart from other county departments. But it is the policy of the board of public works to use existing county departments to avoid the duplication of functions within any one department.

Thus, the department of public works utilizes the county corporation counsel's office for all legal matters. This office is joined by special counsel when bond issues are in process. The county personnel division handles the personnel matters for the department. All purchases are made through the county purchasing department. Payroll and general accounting are handled by central payroll and accounting, and the county treasurer's office is called on for advice about the investment of funds. Advice is frequently asked of the staff of the planning department and drain office, which are compensated for their services. For example, the department of public works now has a \$35,000 contract with the planning department to develop population and land use inventories and projections for the twelve townships involved in the Clinton River project. The department utilizes employees of the drain office, whose time is charged to the particular project; the drain office is thus reimbursed.

It may be of interest to note that the aim of the department is to be an entirely self-supporting agency, not another bureau of county government dependent on county taxes for its existence. This aim can be accomplished if the areas that receive the benefits from the projects developed by the department pay for its cost of operation. Table 1 shows budget appropriations, expenditures against the budget, and total expenditures of the department.

One of the major expenditures of the drain office is the payment to the city of Detroit for the transportation and treatment of sewage from the Southeastern Oakland County Drainage District. The funds for this payment are derived from charges made to the various municipalities utilizing this system.

During 1960, the expenditures of the department of public works will reflect a similar situation, because of the operation of the Evergreen and Farmington systems which will necessitate large payments to Detroit. The data in Table 1 are shown only to emphasize that the department of public works is not intended to be another governmental bureau for which large sums of tax moneys are required.

It should also be pointed out that during the past 2 years, the department has been able to raise funds through advances by local units of government and through some loan advances from the county. As a matter of fact, \$100,000 was recently borrowed from the county to construct the system for the Michigan State University of Oak-

land. The department is paying the county 3 per cent interest on this money, which will be repaid to the county general fund from charges made for connections to the system.

It is assumed that by 1960, the department will be entirely self-supporting. The data in Table 1 show all departmental expenses, including the rent paid to the county for office space and the cost of janitorial services, heat, light, and water. Not included are the county's contribution to the employees' pension fund and certain payroll costs of the central payroll division of the county. The department is, however, attempting to determine what these costs are, so that it can repay the county and truly be a self-supporting organization.



Cost Comparison of Unmetered and Metered Systems at Idaho Falls

—Donald F. Lloyd—

A paper presented on Oct. 8, 1959, at the Intermountain Section Meeting, Pocatello, Idaho, by Donald F. Lloyd, City Engr., Idaho Falls, Idaho.

THOSE responsible for water supply are generally familiar with the usual problems involved in developing and delivering water in an unmetered system. Idaho Falls, Idaho, has been particularly concerned with the practical problem of how to promote metering among the customers of its unmetered water. It was suggested that a simple dollars-and-cents cost comparison would appeal both to the customers and to the city administration.

Existing Conditions

Idaho Falls has approximately 30,000 people, and is located on the plains area of the Snake River Valley, underlaid completely with a lava rock formation. The overburden is 0-40 ft of river gravel and sand, with generally a few feet of topsoil. The water system has an estimated value of \$2,500,000, and is operated on a budget of about \$250,000 per year. The water supply is developed entirely from wells. At the present time, eight wells are operating, with a total rated capacity of 23,600 gpm. There are more than 100 mi of water main in the distribution system, only 15 mi of which consists of 8-in., 10-in., and 12-in. pipe. More than half the total distribution system consists of 4-in. pipe. About 58 of the services supplying customers using large quantities of water are metered, representing only 6 per cent

of about 9,500 services. By partially metering the water at each well, the city has estimated its water consumption to be approximately four times that of the national average, or about 475 gpcd. The range of pressures throughout the distribution system is 15-115 psi, varying mainly with the weather at the time.

Realizing the need for a definite improvement program, the city administration recently authorized a consulting engineering firm to make a comprehensive study of the system. One of the first requirements of such a study was to determine the use rate. This was done by isolating a completely built-up section of the city in which the population density and the number of customers could be determined. A peak hour use was then measured for this area and compared against the total production for that particular day. By prorating this recorded use rate to the peak day production for the season (24.4 mgd), the city was able to determine a projected peak use rate. It was realized that this same use rate would not apply for the entire city, which was then divided into high, medium, and low use-rate areas. A trial-and-error solution was then necessary to have the assumed peak hour rates of the various areas equal to the peak hour rate for the entire system (37.7 mgd). It had previously been deter-

TABLE 1
Summary of Well Costs at Idaho Falls

Well No.	Year Installed	Total Cost \$1,000	Rated Capacity 1,000 gpm	Cost* \$/gpm
1	1927	59.7	3.2	18.65
2	1930	42.0	3.0	14.00
3	1933	50.3	3.4	14.80
4	1948	115.3	4.8	24.00
5	1952	41.0	4.0	10.25
6	1954	96.8	1.1	88.00
7	1957	31.3	1.1	28.45
8	1959	66.3	3.0	22.10
Totals		502.7	23.6	

* The average cost is \$21.30 per gallon per minute.

mined, by metering at each well, that the peak day use rate was 64 per cent of the peak hour use rate. It was determined then, by this method, that the peak day use rate of 2,540 gpd per connection, and the peak hour use rate of 3,930 gpd per connection, would characterize the Idaho Falls water system. Having thus established the use rate of the system, it was next necessary to determine the percentage that consumption was reduced through the use of meters. It was the experience of the consulting firm that about a 50 per cent reduction in consumption could be expected after converting from an unmetered to a metered system. The firm had recently completed a similar study for another city of comparable size, which was entirely metered. A comparison of the two cities showed a peak day reduction of 48.5 per cent and a peak hour reduction of 62.5 per cent. These percentages then were applied to the Idaho Falls system to predict the demand if it were to become entirely metered.

Effects of Metering

People in the water supply field are becoming more and more conscious of

the need for metering, but this need is not so obvious to city administrations. To people in the industry, there are several well established and accepted advantages of using meters. The use of meters:

1. Provides for an accurate accounting of the water used by each customer
2. Eliminates waste and misuse
3. Provides an equitable distribution of the cost of supplying water
4. Makes possible an accurate determination of the water used and lost
5. Provides a means of establishing a good and equitable rate structure
6. Actually reduces the cost of water production and delivery to the customers
7. Eliminates an unnecessary overload of sanitary sewers.

In contrast to the advantages, many citizens have voiced such objections to the use of meters as these:

1. If the city had meters, water bills would be very high.
2. Meters cost money to buy, to install, to read, and to maintain. How, therefore, can money be saved?
3. The use of water for gardens and lawns would be diminished, thereby materially affecting the appearance of the city.

TABLE 2
Cost Estimate for Developing 3,000-gpm
Well at Idaho Falls

Item	Cost \$
Site, drilling & testing	27,000
Pump and controls	15,000
Well building	14,000
Interior piping	1,200
Metering	1,300
Chlorination	2,500
Subtotal	61,000
Contingency	3,000
Total	64,000*

* Thus, the cost was \$21.33/gpm.

These, of course, are objections that must be reckoned with before meters can be promoted. But it was believed to be far more important first to convince the administration of the need for the use of meters and then, with the administration's backing, to convince the public.

Method of Analysis

It seemed logical to state the problem to the city council by asking a simple question: Is it more economical to continue developing a supply of water at the present rate or to install meters? Further, it appeared logical that the administration, like any other, would be interested in a simple dollar-and-cents evaluation of the costs of supplying water to the customers with and without the use of meters. It seemed obvious that the answer would serve to remove any doubt in the minds of the city council that meters should be mandatory. In the development of the analysis, use was made of all factors that would be involved in arriving at the true cost in each instance. After a cursory examination, however, it was decided to eliminate the effect of the distribution system on the total cost, because a study of this factor was beyond the city's present capabilities and therefore would be studied in detail by the consultants. Aside from the distribution system itself, the factors affecting the total cost of supplying water were considered to be: (1) developing the supply, (2) delivering the water, and (3) installing the meters.

With regard to developing a supply for both the metered and unmetered systems, a well production of 3,000 gpm was selected as the basis for determining costs. As shown in Table 1, the development of a supply over the past 32 years has been a considerable

gamble as regards cost. It is surprising to note, however, that the cost of drilling a well has not increased at the same rate as other construction. The average over the 32 years (based on reasonably reliable information) appears to be about \$21.30 per 1 gpm. During the summer of 1959, a local firm gave the city a proposal for drilling wells at a cost in proportion to well production. This cost represents the site, the hole, and test pumping only. Other costs of the well can be seen in Table 2, which shows an estimate based on experience with the newest well in Idaho Falls. It is interesting to note, without any particu-

TABLE 3
*Comparative Cost Analysis of Supply Systems
at Idaho Falls*

Item	Cost in Unmetered System \$	Cost in Metered System \$
Supply development	1.50	0.30
Water delivery	12.00	7.40
Meter installation		3.50
<i>Total</i>	13.50	11.20

lar significance, that the cost per 1 gpm is nearly identical to the average cost over the past 32 years. A well producing 3,000 gpm is estimated to cost about \$64,000. Based on the use rate previously calculated, this well should provide service to 1,400 consumers. By projecting a conservative growth rate of about 350 people per year, one can estimate that a new well of this capacity would be required every 4 years, or cost \$16,000 per year. When the assumed total number of services after the first new well is selected, the cost breaks down to \$1.50 per year per service for developing the supply without meters.

For a metered system, similar calculations show that at the same growth rate the present supply would satisfy needs for about another 12 years. After that time, a 3,000-gpm well would be required, and one additional well every 8 years thereafter. If the same mathematical procedure is used as before, 30 cents per year per service appears to be a reasonable estimate of the cost of developing a supply with meters installed.

The second item of cost comparison—delivering the water, with and without the use of meters—was considered next. With the records available, it was determined that it costs about 2.3 cents per 1,000 gal to deliver water. This cost includes only power, chlorine, chlorine attendant's salary, and pump attendant's salary. The product of this average cost and the average use per service is about \$12.60 per year per service. Again, from sketchy available records, total costs were averaged over the last 3 years and divided by the average number of services during this period. The result was \$10.50 per year per service. As both values appeared to be in the same range of cost, \$12.00 per year per service was arbitrarily selected as the cost for delivering water without meters.

If water meters were used, the cost of delivering water would be reduced. First, the power and the chlorine costs would be directly proportional to the production or the quantity of water delivered. Power and chlorine represent 75 per cent of the total \$12.00, or \$9.00. The remaining \$3.00 represents salaries, and will not be affected. Meters would reduce the production by 48.5 per cent of \$9.00, or by \$4.40.

Together, \$4.40 and \$3.00 make a total cost of \$7.40 per year per service for delivering water with meters.

The last item of cost in this analysis involves the meter installation. It is realized that there is a wide range of estimated costs for meter installations, depending on the local circumstances. In light of the reliability of the foregoing analysis, cost of materials was estimated at \$50.00, and cost of labor at \$20.00, for a total of \$70.00 per service. Furthermore, city experience indicates that an arbitrary selection of a 20-year meter life is conservative. The total of \$70.00 divided by 20 years gives a meter installation cost of \$3.50 per year per service.

This analysis is summarized in Table 3. As shown in the table, the total cost without the use of meters is \$13.50, as compared to \$11.20 for the metered system.

Conclusions

There may be questions concerning the conclusions that can be drawn from this analysis, and the significance of the \$2.30 difference. The analysis itself, and the records on which the analysis was based, are not sufficiently accurate to qualify this difference as conclusive evidence that a saving of \$2.30 per connection will be realized with the use of meters. It can be concluded, however, based on the factors that have been considered, that the installation of meters is economically feasible and warrants serious consideration. It also may be concluded that any savings in the distribution system not considered here would further tip the scales in favor of meters, and a greater cost savings could be shown.

Internal Repairs of Concrete Conduits at Cleveland

Roy M. Mumma

A paper presented on Oct. 29, 1959, at the Ohio Section Meeting, Dayton, Ohio, by Roy M. Mumma, Supt. of Distribution, Water Dept., Cleveland, Ohio.

AT Cleveland, Ohio, at the Division Filter Plant, a two-duct concrete conduit 600 ft long conveys water from the filters to the reservoir. This conduit, which is 12 ft underground and 9 ft below lake level, had been in continuous service for more than 40 years when it was found to be leaking at a rate of several million gallons daily. During past years numerous repairs had been made on the outside of the conduit. The idea of making internal repairs seemed absolutely impossible as it was conjectured that so much water was leaking through the 12-in. concrete dividing wall separating the two conduits that draining would be impossible; moreover, one conduit had to remain in service to supply the west side of the city with water while the other was being repaired. The capacity of each conduit is 110 mgd and the demand at the plant does not fall to less than that quantity until mid-winter.

Preliminary Inspection

In order to determine the feasibility of draining each conduit for making repairs on the inside, a contract was negotiated to have three divers inspect the entire length of each 5.5 ft square conduit, while it was under the nor-

mal pressure of 25 ft of head. Stop planks were placed (Fig. 1), isolating the conduit from the reservoir at the overflow well, and a valve was closed at the filter end, thus stopping all flow during the inspection. The inspection revealed some serious cracks in the concrete near the reservoir and at a point under the street where the conduit drops 4.5 ft to pass under a large sewer; some honeycombed concrete was found at the filter end (Fig. 2), and all of the vertical circumferential construction joints were leaking. With these exceptions, the concrete interior was found quite firm and sound.

Dewatering of Conduit

Based on this report by the divers, permanent repairs to both conduits were recommended. Before work could be started, however, a way had to be found to dewater the conduit at the low point under the sewer. Many ideas were tried and failed. Finally, a 13-ft diameter liner plate shaft was centered over the two conduits and two 36-in. diameter steel access manholes were anchored to the existing concrete, one over each duct. A 1 ft reinforced-concrete slab was placed around these manholes and anchored to the existing concrete to take an upward thrust of 9,000 psi on the manhole cover.



Fig. 1. North Conduit Stop Planks in Place

This photograph was taken at a late stage in the repairs; pressure concrete patches had already been made.



Fig. 2. Honeycombed Concrete in North Conduit

The deteriorated condition shown necessitated the repairs illustrated in Figs. 3 and 4.



Fig. 3. Hose Inserts and Wire Mesh in Place

After application of pressure concrete over the mesh, cement grout was forced through the hose inserts to fill any voids.

The water was pumped out at the overflow well by an 8-in. gasoline pump while the concrete was being cut out through the access manhole. A 6-in. gasoline pump with a 6-in. hose, reaching into the lowest point at the dip, was able to drain the entire conduit and keep it empty of seepage water. A similar shaft and two 36-in. diameter steel access manholes were placed at the other end of the conduits. As a safety precaution, the south conduit was kept dewatered for several days before it was entered. The inspection made after dewatering confirmed the divers' report that permanent repairs to both the north and the south conduits were feasible.

Repair Methods

All deteriorated concrete was removed, and 2×2-in. 12-gage galvanized wire fabric was anchored over the honeycombed area (Fig. 3), and pressure concrete was placed over the wire mesh (Fig. 4). Cement grout was then forced through inserts to fill all voids in the old concrete behind the pressure concrete. Rubber expansion joints were placed over fifteen vertical construction joints with pipe inserts to drain leakage until galvanized wire fabric and pressure concrete were placed over the rubber (Fig. 5). A $\frac{3}{4}$ -in. sponge rubber fin, cemented at right angles to the center of the 7-in. wide flat rubber joint, protrudes through the pressure concrete seal and permits expansion and contraction.

At the east slope of the dip, where cracks indicated possible failure and where much water was seeping back into the dewatered conduit, 24 $\frac{3}{4}$ -in. rubber hose bleeds were placed and sealed with a quick-setting pressure concrete to keep the surface of the old concrete dry while pressure concrete was placed over a cage of $\frac{3}{8}$ -in.

reinforcing steel bars anchored to concrete. Cement grout was forced through inserts placed where the bleeds were removed, thereby filling all cracks in the old concrete walls. The severe diagonal cracks around the walls and floor of the conduit near the overflow well at the reservoir were repaired in the same manner. The deteriorated coating found on the surface of the old concrete was removed by sand blasting and a metallic, nonshrinking, cement-



Fig. 4. North Conduit After Application of Pressure Concrete

This is the same portion of the conduit, after repairs, as that shown in Fig. 2.

sand grout was applied by pressure over the entire surface and length of the conduit.

Completion of Work

Repairs in the south conduit were begun Jan. 2, 1957, and were completed by Mar. 15, when the conduit was filled with water. Then, on Mar. 19, 1957, the north conduit was dewatered, the concrete cut from the interior of the two access manholes, one at each end, and the contractor began repairs.

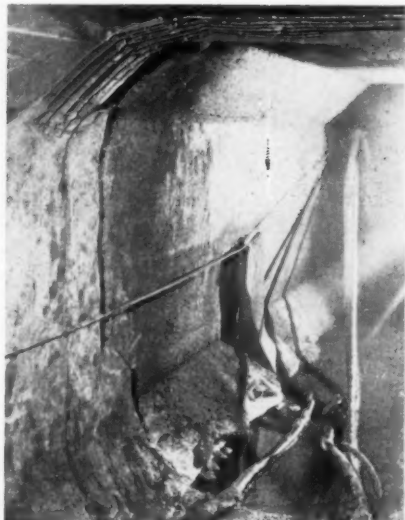
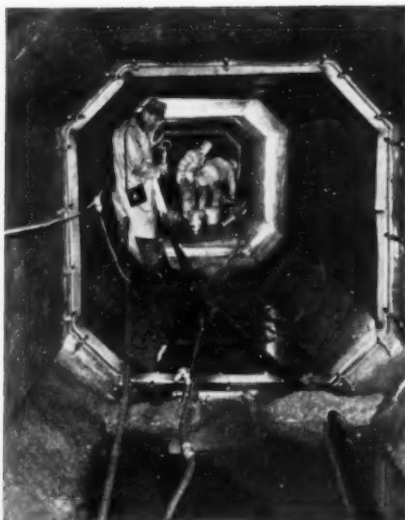


Fig. 5. Installation of Rubber Expansion Joints

The rubber expansion joints are here shown before and during application of pressure concrete. The walls had been sandblasted but the grout had not been applied.

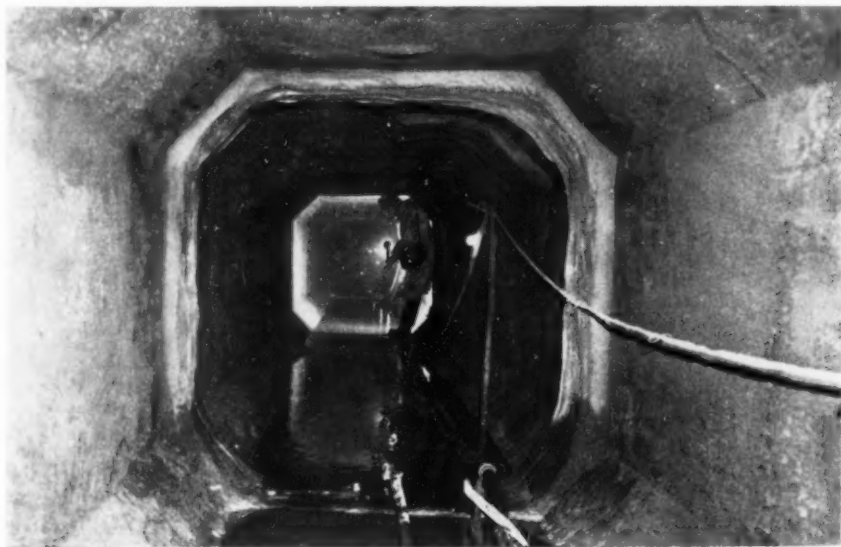


Fig. 6. Completed Expansion Joints and Patches in North Conduit

This picture was taken after the application of grout.

Repairs of the north conduit (Fig. 6) were completed in one third the time required for repairing the south conduit, because no water was seeping from the south to the north conduit. Some water did seep in from the ground, as the invert of the conduit is 9 ft below lake level. The same procedure was followed as was used in repairing the south conduit. Work was completed Apr. 16, 1957. The cost was only 8 per cent of the estimated \$1,000,000 cost of new conduits.

A brick vault was built over the pairs of access manholes at each end of the conduits. These vaults will provide

easy access to the conduits for future inspection.

At several sewer manholes near the conduits, inspection shows no leakage now, where there was considerable flow before. The contractor claims he hasn't found any concrete yet that he could not repair effectively.

Acknowledgment

All preliminary work and the dewatering were done by the division's tunnel maintenance crew. Thanks go to this crew, and to all who contributed to the successful completion of the project.

Coagulant Aids for Potable Water Treatment

The USPHS Technical Advisory Committee on Coagulant Aids for Water Treatment has added the following products to the list of those that may be used for water treatment—in the concentration recommended by the manufacturer—without adverse physiological effects on the consumers: Illico IFA 313, manufactured by the Illinois Water Treatment Co.; Claron 207, manufactured by Allyn Chemical Co.

The committee's findings bear only on the health aspects of the use of these products and do not constitute an endorsement or indicate their effectiveness in the proposed use. The names of other coagulant aids on the committee's list were published in the February 1959 issue (p. 233), the May 1959 issue (p. 574), and the January 1960 issue (p. 152) of the JOURNAL.

Leak Surveys and Control of Unaccounted-for Water

Joint Discussion

A joint discussion presented on Oct. 8, 1959, at the Chesapeake Section Meeting, Baltimore, Md.

Program at Baltimore—Karl H. Schamberger

A paper presented by Karl H. Schamberger, Prin. Engr., Div. of Conservation, Bureau of Water Supply, Baltimore, Md.

IN December 1957 the Bureau of Water Supply of the Department of Public Works, Baltimore, Md., activated two crews to detect and locate unreported leakage. These crews, known as sonic-survey crews, were assigned to a new conservation division.

The program for the conservation division as planned utilizes an organization consisting of four sections: (1) administrative, (2) sonic leak survey, (3) instrument, and (4) pitot meter water leak and waste survey.

Personnel are at work for all of the sections except the pitot meter water waste survey, which has been deferred until a supervisor with the required engineering training is available. The bureau owns the flow-measuring equipment needed to pursue a pitot meter survey. The equipment was purchased in 1920 and was used through 1932 in a well organized water leak and waste survey. In 1932, owing to budgetary restrictions, the survey was reduced to a house-to-house inspection program, which was finally discontinued in November 1945 with the retirement of the last inspector.

Nature of Survey

The work of the sonic survey crews is a modification of a house-to-house inspection program. Each crew, as now staffed, consists of a foreman, a laborer-chauffeur, and a laborer. Experience gained during the 22 months the survey has operated shows that an additional laborer is needed to bring the operation to peak efficiency. The foreman plans the day's work from sectional maps of the distribution systems. These maps can be carried in the field without inconvenience. They show the mains, valves, and fire hydrants in the system, but they do not show water supply services.

In those areas of the distribution system where all water supply services are metered, contact is made with every valve and fire hydrant by means of a steel rod or an aquaphone. If the distance between these appurtenances indicates a need for additional listening stations, water supply services are contacted also. In flat-rate areas, every water supply service is used as a listening station so that leaks inside the curb stop can be detected.

The Baltimore distribution system, which includes portions of the counties surrounding the city, is divided into five zones. The two zones supplying the lower elevations in the distribution system are gravity systems, whereas the three supplying the higher elevations are pumped-storage systems. The sonic-survey crews began their work in zones with pumped-storage systems. These zones furnish water in areas where the street paving is frequently macadam, the homes are of the cottage type, duct lines are nonexistent, and conditions are generally favorable for leakage to rise to the surface.

The major parts of the distribution facilities in these systems are of recent construction, most of them having been constructed in the last 20 years. Installations made in the areas must meet the specifications of the Bureau of Water Supply for materials and leakage before the work is accepted for maintenance by the bureau. All construction is supervised by a representative of the Bureau of Water Supply. Leaking mains, valves, fire hydrants, and services uncovered by the survey crews in these areas were scattered and few in number. This was so true that it caused the workers to voice discouragement. As the work has moved into the older areas of the distribution system, where flat-rate services are found, the number of leaks has increased and the crews are now convinced that their work is important.

A statistical resume of the sonic-survey work shows that 1,491 mi, or 63 per cent, of the mains in the distribution system as of Dec. 31, 1958, were covered between Dec. 1, 1957, and Aug. 31, 1959. The leaks detected and located totaled 414, of which 93 were found in customers' piping.

Any investigation of a distribution system brings to light many conditions that need correction if the system is to be kept in order. The survey has issued 669 orders for raising valve vaults and roadway boxes to grade. In all, it has located and uncovered 1,051 valve vaults and roadway boxes. Owners of 331 properties have been notified to correct faulty curb boxes.

It is accepted water utility practice to gather data on the output of the plant and the water used by consumers so that an estimate may be made of unaccounted-for water. Leakage may be a major part of this water. In addition to leakage, unaccounted-for water includes water passed by meters but not registered; water used in main, street, and sewer flushing; water used in fighting fires; water used on construction projects; and water used illegally.

In systems where all services are metered, the determination of unaccounted-for water is simple; the difference between master meter readings for the system and the sum of the readings of consumers' meters provides the answer.

Service Zones

The Baltimore water service area is divided into five service zones and the three zones supplying the highest elevations are pumped-storage systems. These zones are known as Zones 3, 4, and 5. All water supply services in Zones 4 and 5 are metered. Also, all the area supplied by these zones is situated in Baltimore County, with the exception of a few acres at the northern city boundary. In order to establish a basis for accounting for the quantity of water supplied to Baltimore County, studies were made of the input and

consumption in these zones for the years 1946-51. The percentage of water pumped into the zone but unaccounted-for ranged from a low of 12.8 per cent in 1951 to a high of 17.3 per cent in 1949. The average for the six studies was 15 per cent.

The total amount of water pumped into these zones equals approximately 4 per cent of the total supplied to the service area. For estimating purposes, the average demand for the Baltimore service area, in round numbers, is 200 mgd. The data for the years 1951-58 show that the demand has varied between 197.1 and 199.6 mgd, the average for the 8 years being 197.5 mgd. On a basis of 200 mgd, Zones 4 and 5 together use approximately 8 mgd, of which approximately 1.2 mgd is unaccounted for.

The water supply services in Zones 1, 2, and 3 of the Baltimore system are a mixture of metered and unmetered accounts. Prior to October 1951, applications for unmetered services were accepted for dwellings of one-family occupancy if situated within a former boundary of the city of Baltimore established in 1888. All services for properties located beyond this boundary and for industrial properties are metered. The mayor's committee on water rates, in its report of October 1951, recommended a stepped-up program for converting flat-rate accounts to metered accounts, and the bureau has averaged about 2,500 conversions annually since then.

As of Dec. 31, 1958 the system contained 112,115 domestic and commercial unmetered services. This is equivalent to 50.4 per cent of the domestic and commercial services within the city boundary. No estimate has ever been made of the distribution of

these flat-rate accounts among Zones 1, 2, and 3.

An analysis of water use in systems supplying unmetered services is not so easy to make as for a fully metered system. If, however, an acceptable value can be found for the per capita consumption in the system after leakage surveys have been made, a reasonable estimate of unaccounted-for water may be developed, if the water used through industrial meters is known. The total water furnished the system, less industrial water use, leaves a value for the water used domestically and commercially, including water unaccounted-for.

Leak Detection

An organization to detect and correct leakage was established in Baltimore in 1913. Pitot rod meters and a portable recorder were used in the work. To increase the efficiency of this waste detection program, a firm of consulting engineers was employed during 1920 to survey a selected area of the system and to instruct personnel of the bureau in leak detection techniques. The work was continued by bureau personnel alone until 1932.

In reports for the surveys made during 1920-24, data were recorded on daily domestic per capita consumption after leakage correction.

Reports for 27 survey sections in Zone 1 present consumption data for 193,883 people or for 62 per cent of the estimated resident population of the zone in 1920. The domestic and commercial consumption recorded after completion of the survey, or during re-measurement, was 102 gpcd.

For seven sections located in Zone 2, with a population of 93,858, or 38 per cent of the estimated 1920 popula-

tion, remeasurement showed a domestic-commercial use of 69 gpcd.

The per capita consumption values are for unmetered services. They include a small amount of unaccounted-for water. The occupants of the houses in the sections were made aware of the significance of water waste by the house-to-house program carried out as part of the survey. No industrial consumption enters into the per capita calculation. Commercial use, however, is included, the reports showing that few commercial properties were metered at the time of measurement. The consumption figures are for consumers resident in the city of Baltimore only, the water service area not expanding into the counties until 1923.

Estimation of Total Unaccounted-for Water

A detailed estimate of the industrial and domestic-commercial use of water for the Baltimore service area for the year 1957 has been developed by the fluid-network analyzer staff of the water supply bureau. Both use and population estimates were made for the political and zonal divisions in the supply area.

From the table of estimates, it was determined that average total water use in that part of Zone 1 within the city, including unaccounted-for water, was 46 mgd, with an average day of 200 mil gal. Industrial use in the area on the average day was estimated to be 47.4 mil gal, this estimate being based on the registration of all the industrial meters, but not including unaccounted-for water.

If it is assumed that the use habits of the residents of the city area of Zone 1 have not changed appreciably from 1920 to the present, the domestic-

commercial use in the area for a 200-mil gal day is at a rate equal to a per capita consumption of 102 gpd for 342,000 people, or 35 mgd. This value subtracted from the estimated domestic-commercial consumption, including 46 mgd of unaccounted-for water, indicates that the unaccounted-for water in the city area of Zone 1 is 11 mgd. All services in the area in question are metered, and as 15 per cent of the water entering county areas was found to be unaccounted for, the unaccounted-for water in the county area of Zone 1 is 15 per cent of 14.6 mgd, or 2 mgd. The total unaccounted-for water in Zone 1, therefore, is estimated to be 13 mil gal on an average day.

A similar determination, using the per capita value for the pitot survey sections of Zone 2 and the same county percentage used for Zone 1, shows that losses totaling about 10 mgd would occur in Zone 2. Applying the pitot survey data from Zone 2 to Zone 3, where there also are a number of unmetered services, and according to the procedure outlined above, the losses in Zone 3 are estimated to be 8 mgd. The losses for Zones 4 and 5 have been stated to be a little more than 1 mgd. The total estimated unaccounted-for water for the Baltimore system for an average day may be 32 mil gal, or 16 per cent of the water supplied the system.

Leak Control Measures

Although Baltimore did not engage in leak survey programs of any magnitude from 1932 to 1957, the bureau did adopt practices that have value as deterrents to leakage. In 1915, the bureau adopted pressure and leakage testing of mains in advance of improvement of the street pavement. Water supply

services were overhauled in preparation for the improvement. This work is continuing, and all new main extensions are subjected to a test for 30 min at a pressure equal to 150 per cent of the working pressure for the installation and to a leakage test in which the allowable leakage is 50 gpd per inch-mile. These requirements are subject to some modification, depending on the size and location of the main.

The use of braided, square packing for joints was adopted in 1923. Copper service pipe for $\frac{3}{4}$ -in. and 1-in. services was adopted in 1925. In that year the city assumed the cost of maintaining water supply services between the main and the curb stop. Bell joint clamps for repairs and for difficult situ-

ations have been in use since before 1941. Within recent months, the use of single-gasket pipe has been adopted. For several years O-ring packing has been a standard for new valves. Of equal value with the adoption of new materials was the adoption, in 1926, of a book of standards covering the installation of all water supply appurtenances.

Conclusion

By reactivation of its leak detection program, Baltimore has reduced the unaccounted-for water, which is lost from the system at an estimated rate of 32 mgd. Baltimore has been able to hold it to a minimum by the adoption of sound works construction and maintenance procedures.

Practices in the District of Columbia

Roy L. Orndorff

A paper presented by Roy L. Orndorff, Deputy Director, Dept. of San. Eng., Washington, D.C.

Unaccounted-for water is a major problem that has arisen in the operation of public water supply systems at least since the time the Roman aqueducts were built, and probably before. The only remedy, obviously, is simply good management. If, for example, a system produces 20 mgd and can account for only 15 mgd, the unit cost of collection, treatment, pumping, and distribution is the same for the 5 mgd that is lost as for the 15 mgd that is usefully consumed.

Some important tools are available to water utility management for reducing unaccounted-for water. The District of Columbia system has accomplished much in the direction of leak controls; although it is not intended to hold up the District of Columbia system as a model, a discussion of what

has been found feasible in one typical large distribution system may be useful.

Definition of Unaccounted-for Water

Unaccounted-for water is the difference between the metered quantity delivered to the system and the quantity recorded through consumer meters, with sensible adjustment for such factors as flat-rate sales, underregistration of meters, fire-fighting, street and sewer flushing, water use on municipal construction, and normal, unavoidable pipe leakage. Unaccounted-for water is usually expressed as a percentage of metered delivery to the system. Many local factors affect this percentage from system to system, but, in general, 10-15 per cent is considered indicative of good management and good conservation practices.

Means of Control

At the head of the list of means available to control unaccounted-for water, are utility personnel. Any program of control can have no hope of success in the absence of an adequate staff of capable, interested, and, most important, persistent people to keep it going. Obviously a municipality that relies upon a single paid official to act as chief of police, fire chief, street superintendent, and manager of the sewer and water departments can expect little in the way of good management of its water system.

With a competent staff, the first physical objective toward controlling unaccounted-for water should be complete metering of consumer services. The simplest way to reduce the unaccounted-for portion of the water delivered to the system is to account for as much as possible of the latter by metering it. Without the data provided by complete metering, there can be no assurance of reliability in any computation of the unaccounted-for percentage. This has been a vital question in the District of Columbia for the past 70 years, and, in spite of long cycles of meter and flat-rate policies, the author is happy to be able to report that 99.8 per cent of District of Columbia services are metered.

The next important step, and this may well be just a part of complete metering, is the provision of an adequate meter maintenance program. As it is characteristic of standard water meters that failure or partial failure almost always results in underregistration, the cost of reasonable maintenance of meters should be one of the easiest costs for the utility manager to justify to the budget-authorizing body. It is generally accepted that meters should be removed for replacement or repair

at intervals of no more than 10 years' length. Here again, although the District of Columbia system has been through some unfortunate cycles, it is now embarked on a program of rotation of domestic meters at 10-year intervals, and at shorter periods for larger meters.

To complement the meter installation and maintenance programs, a survey may be undertaken to locate, identify, record, and control those uses of water that, for one reason or another, are not susceptible of metering. This is really a difficult thing to undertake, as it involves obtaining the long-range cooperation of many municipal agencies that are outside the control of the water department and have no direct interest in the water management problem. In addition, such a survey must be held on a continuing basis. It is doubtful that any utility will ever reach the point at which it is satisfied with the estimates it makes for nonmetered uses, but, nevertheless, it should strive for the best possible accuracy.

Correction of Leaks

Once the utility has provided, through the programs already mentioned, a means for measuring the useful consumption of water from the system, either by direct metering or by estimating, the next objective should be the location and correction of abnormal leakage and other losses. This may be accomplished by a program of inspections of various kinds, including routine operating tests of valves and hydrants, and by water waste surveys. The scope of such inspections will be obvious to the experienced water engineer. Water waste surveys, being a form of system audit, are extremely valuable in giving both a detailed and an overall record of the flow of water from the system. The surveys con-

sist essentially of dividing the distribution system into sections, or zones, measuring the input into each isolated section over a 24-hr period or longer, evaluating the extent of losses through a comparison of the ratio of the minimum night rate to the average flow rate, tracing and identifying any abnormal flows or significant losses. Such surveys may be undertaken by the regular system staff, but utilities usually use expert and specialized outside assistance, which is available at reasonable cost.

Frequency of Surveys

Leak surveys should be repeated often enough to detect changing conditions in the system. Generally, more frequent surveys are found to be most profitable in older systems or older sections. This is due partly to the age factor in the mains and plumbing and partly to the better materials available in modern construction with such improvements as rubber-packed joints and copper tubing. From the experience of the District of Columbia, start-

ing in the early 1940's, resurveys have been profitable at about 5-year intervals in the older areas, where the mains and houses are generally 60-80 years old, but a frequency of 12-15 years seems sufficient in areas that have been developed in the past 40-50 years. The District of Columbia surveys have located losses ranging from minor joint leakage to an open 12-in. blowoff that discharged about 1 mgd to a drain. One source of significant losses in the system has been an accumulation of abandoned services. At one time there were records of as many as 8,000 of these old services still fed through live taps. A vigorous program, carried on from year to year, has reduced the numbers to a normal backlog of about 1,200.

Conclusion

Some of the essentials of controlling unaccounted-for water have been discussed. There are many tools available, but there is no doubt that the most important ingredient in such a program is human perseverance.

Design and Operation of the Midland Treatment Plant

Joint Discussion

A joint discussion presented on Sep. 23, 1959, at the Michigan Section Meeting, Saginaw, Mich.

Design and Construction—John C. Seeley

A paper presented by John C. Seeley, Cons. Engr., McNamee, Porter & Seeley, Ann Arbor, Mich.

THE new filtration plant at Midland, Mich., was part of a \$3,000,000 water supply improvement program approved by the citizens of Midland in March 1956. Included in the program of improvements were modifications in the existing 7-mgd filtration plant, a 100-mil gal raw-water reservoir, Midland's share in an additional pumping station on the Lake Huron supply main, and a new 8-mgd filtration plant complete with a filtered-water reservoir and high-service pumping station.

The layout of the Saginaw-Midland supply system is shown in Fig. 1. The new filtration plant and raw-water reservoir are located on the east side of the city, adjacent to the 36-in. Lake Huron supply main. This location was decided on because of space limitations at the west-side site. An ideal site was obtained, making possible a very economical earth embankment construction for the raw-water reservoir (Fig. 2). The site also offered convenient rail and truck transportation for bulk handling of chemicals.

Selection of Treatment Unit

In 1956, after the approval of the bond issue, the city officials and the

designing engineers reviewed and considered different methods of treatment. It was desired to provide a water of the same quality as that provided by the west-side filtration plant, which reduces the calcium hardness of Lake Huron water from about 100 ppm to about 60 ppm.

After several months of study, which included visiting a number of plants, it was decided that a multiple-treatment unit,* using the solids-contact process for pretreatment, would be most economical for this particular installation. The system is a unique arrangement of pretreating tanks and filters which was developed about 1950 by E. H. Aldrich. The first installation was made at Alexandria, Va., in 1950, and there have been a number of such installations since that time. In the multiple-treatment system, the two primary components of a treatment plant, the pretreating element and the filters, are combined in a single, compact unit. The pretreatment element is a circular tank, surrounded on its periphery by the rapid sand filters. The water, after it has received solids-contact treatment,

* PeriFilter; manufactured by Dorr-Oliver, Inc., Stamford, Conn.

overflows the circumferential wall onto the filters.

At the time of the investigation for the Midland plant, all of the existing multiple-treatment units were located in warmer climates and consisted of open steel tanks. These steel tanks require considerable maintenance, and it was therefore decided that the Midland tanks would be constructed of reinforced concrete. However, this required that special construction methods be followed in order to prevent any leaking of water from the pretreatment tank into the clear well under the filters. It was also necessary, in order to prevent freezing of the pretreatment tanks and filters during the winter, to house them completely and supply heat to the space above the water.

As stated previously, the capacity of the new plant had been set at 8 mgd. Further studies indicated that, for flexibility, two 4-mgd units would be necessary and that each of these units would have two 2-mgd filters. With this determined, it was possible to proceed with the plant layout.

Pretreatment

Lake Huron water is fed to each pretreatment tank through a venturi meter and control valve, which automatically maintains the tank level at either the primary or secondary level. Constructed of reinforced concrete, each tank is 55 ft in diameter and 18.75 ft deep and holds 340,000 gal. The retention time is 2 hr at the normal rating of 4 mgd. In the annular space around each tank are two rapid sand filters, each rated at 2 mgd.

The water enters the tank through orifices in the bottom of four radial arms which rotate near the bottom of the tank, and the hydrated-lime solution for precipitating the calcium hard-

ness is introduced at the top of these rotating arms. Facilities were provided for adding the coagulant just prior to the time the water entered the tank or in a zone several feet above the bottom of the tank. In the design, provisions were made for use of alum as a coagulant. After several months of operation, however, because of the poor results obtained, the coagulant was changed to ferric sulfate.

The chemicals are mixed with the water at the bottom of the tank by the



Fig. 1. Locations of Facilities of the Saginaw-Midland Supply System

The main pipeline from the Whitestone Point intake is 48 in. in diameter. The branch line serving Saginaw and Midland are both 36 in.

turbulence created by jets of water impinging on the tank bottom. The water then passes upward through a blanket of previously formed sludge. The rotation of the arms keeps the sludge blanket active with an intimate mixture of chemicals, raw water, and previously formed sludge. All chemical reactions occur in the blanket, so that newly formed insoluble salts precipitate directly on the sludge particles

already present. The filtering action of the sludge blanket traps the finer particles and prevents them from passing upward into the clarification zone. The clarification zone extends from the top of the sludge blanket to the surface of the water. The water, after passing through the clarification zone, overflows the circumferential wall to the filters.

In order to maintain the sludge blanket at the proper level, it is periodically necessary to draw off sludge from the bottom center of each pretreatment tank. This is done automatically by an adjustable timing device on each sludge valve and a tripping mechanism connected to the flowmeter of each tank; the timer is tripped after a predetermined volume of water has entered the tank. The sludge from the tanks is discharged to a sludge well, and it is then pumped to one of two sludge lagoons for settling.

Filters

The annular space surrounding the pretreatment tank is divided diametrically in half, and each half is occupied by a rapid sand filter with a capacity of 2 mgd, based on a filtration rate of 2 gpm/sq ft. This annular space is 8.5 ft wide; 1.5 ft of the width is occupied by the wash water gullet, and the remaining width by the filter.

The top of the filter sand is 10 ft below the water surface. The sand bed consists of a 30-in. depth of filter sand, with an effective size of 0.65 mm and a uniformity coefficient less than 1.5. This sand bed is supported on a 12-in. layer of graded gravel stone, which in turn is supported on a monolithic concrete Wheeler filter bottom. Below each filter bottom is a small clear well 6 ft wide, 4.5 ft deep, with a capacity of 20,000 gal.

The filtered water flows in pipelines by gravity from each clear well through rate-of-flow controllers to the filtered-water reservoir.

When it becomes necessary to backwash a filter, the water level in the pretreatment tank is lowered to just below the top of the ring wall separating the pretreatment tank and the filter. One filter is then taken out of service, and the one remaining in service is fed water from a circumferential launder located just below the top and on the tank side of the ring wall and through a gated opening between the launder and filter.

For cleaning the filters, both surface wash and backwash are provided. The surface wash system, used for breaking up the surface of the sand and the prevention of mudballs, consists of fixed nozzles, with each nozzle covering 10.5 sq ft. Untreated water is supplied to the nozzles at a pressure of 70 psi by a booster pump with a capacity of 500 gpm.

The water for backwashing the filter is treated water pumped from the high-service suction well by means of a 14,000-gpm, mixed-flow pump. Water can be supplied by this pump at a maximum wash rate of 20 gpm/sq ft, or a 36-ipm rate of rise. The wash rate is measured and controlled by means of a venturi tube and a cone valve, which are adjusted from the filter control table by setting a knob to the desired wash rate. The wash rate can be varied by the operator at any time during the backwash cycle.

The dirty wash water is carried away from above the sand by radial wash water troughs, constructed of concrete, with the lips set 30 in. above the sand and the troughs spaced 6 ft 6 in. apart from center to center. These troughs discharge into a circumferential

wash water gutter, which, in turn, discharges to the 30-in. and 36-in. wash water drains. The drain line carries the water to one of two wash water lagoons, where the water is clarified before overflowing to a county drain.

The controls for backwashing each pair of filters are on a single control table located on a balcony from which

rate-of-flow and loss-of-head indicators for each filter. All valve control and metering are pneumatically operated. The filter control valves are rubber-lined butterfly valves equipped with pneumatic cylinders. The filtration rate controllers consist of a venturi tube and butterfly valve with a pneumatic positioner and other appurtenances.



Fig. 2. Aerial View of the Midland Plant, Booster Pumping Station, and 100-mil gal Raw-Water Reservoir

The new plant is at the lower left. The booster pumping station is located on the near side of the reservoir.

the operator can view either of the filters. Each control table has switches for operating the five filter control valves for each filter, a control for the influent valve to the pretreatment tank, a wash water rate setter and flow indicator, pushbuttons for starting and stopping the backwash and surface wash pumps, a filter rate setter, and

Except for the backwashing of the filters, it was desired to concentrate all of the meter and control functions, as far as possible, in the laboratory where the operator spends the major portion of his time. Therefore, on one wall of the laboratory there is a meter and control panel 20 ft long and 6 ft high. The meters and controls face the labo-

ratory, and access to the interior of the panel may be obtained by doors on the back of the panel opening into the corridor.

The operator at the panel has the necessary information and controls to regulate the flow of water through the plant and into the distribution system as well as from the Lake Huron pipeline into the 100-mil gal reservoir.

Chemicals and Feeders

There are four chemicals used at the Midland plant: lime is used to precipitate the calcium hardness, ferric sulfate is used for coagulation, fluoride is added to the finished water to assist in the control of dental caries, and chlorine is used for disinfection.

The lime is purchased in bulk as quicklime. It is presently trucked to the plant, but by providing a railroad siding the city can have it delivered by rail in the future. At the plant, the truck dumps its load into a hopper and the lime is carried by a system of screw feeders, conveyors, and a bucket elevator to the top of a 100-ton, reinforced-concrete bin. This bin is built integrally with the building, its bottom extending into the pipe gallery and its top into the chemical storage room. Controls for the chemical-handling system are located on a panel convenient to the laboratory on the main floor. The same system is used to convey the lime from the storage bin to either of the two day bins located above the lime feeders and slakers. These bins have a capacity of 2 tons.

From the day bins the lime is fed at the desired rate through gravimetric feeders, located on the second floor, into pugmill slakers, which hydrate the lime and place it into solution for gravity feeding to the pretreatment tanks.

The lime solution is conveyed to the treatment tanks in open troughs, which are readily accessible for cleaning. The lime feeders are automatically paced by the raw-water meters so that an increase or decrease in flow changes the lime feed rate.

Ferric sulfate is purchased in 100-lb sacks. These sacks are received on the unloading platform at the plant and are loaded on wood pallets. The loaded pallets are then hoisted to the storage room on the third floor level by a hydraulic freight elevator which is provided for this purpose. The ferric sulfate is fed through a single volumetric feeder, located on the second floor level, into a solution tank. The solution then flows to a splitting box which divides the flow to the two pretreatment tanks. The solution is conveyed to the raw water line entering each tank by plastic * pipe.

Fluoride is purchased in bags as sodium fluoride or sodium silicofluoride. The method of handling the fluoride is the same as for the ferric sulfate. The sodium fluoride is fed through a gravimetric feeder automatically paced by the raw-water flow. After the material passes through the feeder it is placed in solution and fed through a plastic pipe to the main filtered-water feed line to the filtered-water reservoir.

Chlorine is purchased in 150-lb cylinders. Two chlorine solution feeders are provided, one for feeding chlorine to the suction well at the booster pumping station and the other for feeding chlorine to the raw water entering the plant or the filtered water entering the filtered-water reservoir. Both chlorine feeders are automatically controlled from flowmeters and are located on the main floor adjacent to the laboratory.

* Uscolite; a product of US Rubber Co., New York, N.Y.

The solution piping at the feeders is so arranged that if one of the feeders is taken out of service the other can take over its duties.

Filtered-Water Storage

After the water is filtered and has been treated with chlorine and fluorine, it flows by gravity to a 4-mil gal storage reservoir. This reservoir, constructed of reinforced concrete, is 214×184 ft in plan and the distance between the base slab and the underside of the roof is 15.5 ft. The roof consists of a flat slab of concrete 8 in. thick supported on concrete columns and covered with 18 in. of earth.

In the design and construction of the reservoir every precaution was taken to exclude entrance of ground water or surface water. This included elevation of the top of the reservoir above the surrounding ground so that all surface water positively drained away from it, the provision of a 6-in. under-drain around the entire periphery of the reservoir, which discharges to a sump in the service building, and the establishment of the normal operating level in the reservoir at about the level of the surrounding ground.

As the reservoir was completed early in the construction schedule, careful observations were made over a period of several months with the reservoir empty, and at no time did surface or ground water enter the tank. After the reservoir was filled, observations indicated no outward leakage of filtered water.

High-Service Pumps

The high-service pumping station is at the east end of the service building, and has space for six deep well high service turbine pumps. There are

three 5-mgd units and one 3-mgd unit presently installed. The pumping station consists of a single level above-ground and two levels underground. The lowest level contains the two suction wells, which are each connected to the 4-mil gal reservoir by a 48-in. pipeline and are, in turn, interconnected by a gated opening. Either suction well may be dewatered for inspection or cleaning while the other is in operation.

The bowls of the deep well pumps hang within a few inches of the suction well floor, which is at an elevation 4 ft below the filtered-water reservoir, so that it permits full utilization of the water stored in the reservoir.

The intermediate level contains a 24-in. discharge loop with connections to each of the four presently installed pumps and to two 24-in. mains connected to the city distribution system. The pumps are connected to the discharge loop through cone check valves. The loop is valved so that any unit can be isolated on the loop.

The ground floor level contains the driving motors, electrical switch gear, and overhead crane. The upper part of the walls and the ceiling are faced with sound-deadening material so as to reduce to a minimum the noise from the motors. Two sources of electricity are available to the plant: the main source from the local public electric utility and an emergency source from a nearby chemical company that generates its own power.

Provision for Expansion

Provisions have been made in the present construction for two additional treating and filtering units located west of the present tanks and for expansion of the filtered-water reservoir to 8 mil gal.

Costs

The construction cost of the treatment plant, filtered-water reservoir, and high-service pumping station was

\$1,490,000. Although it is always difficult to compare costs of construction, it is estimated that the city saved more than \$200,000 by using the multiple-treatment unit.

Startup and Operation—Charles A. Froman

A paper presented by Charles A. Froman, Supt. of Utilities, Midland, Mich.

The job of putting the new Midland, Mich., treatment plant into operation was unique but comparatively easy, because water for the city was being supplied from an older plant at a different location. Operation of the new plant could therefore be started and stopped as desired without interrupting water service to the city. Each time it was found that a major alteration or adjustment was needed, the plant was shut down, if necessary, and the problem was solved. Although it was time consuming, this method was ideal from the management standpoint, as it allowed a complete check of the plant under actual operation without its being necessary to live with problems because of an inability to shut down. The plant was placed into limited use for 6 weeks while minor modifications were being made in controls and while the contractors were completing some of the finishing touches. The plant is pneumatically controlled, with a number of automatic features; many of the early mechanical troubles were instrumentation problems. A view of the plant is shown in Fig. 3.

Operator Preparations

In planning for operation of the new water plant, only one new operator was hired 6 months before the new

plant went into operation. It was planned that the rest of the operating staff would be shifted from the old plant and the old plant would be shut down for renovation. The hiring of a new operator made it possible to schedule one operator at the new plant during the day shift each week. Thus each operator was able to follow some of the construction and installation of the equipment before it was put into operation. Operator instruction classes were also started; at first, emphasis was placed on the new types of equipment in the new plant, and gradually the instruction was shifted to water mathematics, chemistry, and bacteriology. Although some of the operators had been working at the old plant for many years, none had attempted to become certified operators. Since starting the training program, however, each operator has taken a certification examination and now plans to take the next higher exam in the spring. Because of the favorable reactions to the classes, it is planned to continue formal classes for a 2-hr period each week indefinitely, except during the summer months. As the old treatment plant was a softening plant using split treatment, the operators were quite familiar with the general softening process the transition to the new plant was not difficult.

Mechanical Problems

In the initial trials, it became apparent that smooth operation, mechanically at least, would depend to a large degree on the proper functioning of each instrument and control. Many man-hours were devoted to testing and adjustment by the contractor, consulting engineers, instrument service men, and city personnel. It took more than 6 months of periodic trials and readjustment to get the plant mechanically functioning as desired. It was finally necessary to build a laboratory for pneumatic testing, so that differential

One of the first problems encountered in attempts to start the new plant was that no provision for manual influent flow control was made in the original design. This meant that any time the treatment tanks were not up to operating level, the influent valves would open fully and water would enter at the highest rate that could be sustained by the raw-water supply system. As radical flow changes cannot be tolerated on the Saginaw-Midland system, manual controls were designed for the influent valves. The design, ordering, and installation held up the scheduled starting time, but, as the



Fig. 3. Service Building and Pretreatment Tanks and Filters

This building houses the office, laboratory, and treatment units. Another principal structure is a 4,000,000-gal concrete reservoir which is completely underground.

pressure transmitters, relays, square-root converters, and test pressure gages could be tested against manometers. Spare units for all major controls were bought and, when trouble develops, they can be adjusted in the laboratory and then installed. The faulty unit can then be checked on the laboratory bench and adjusted, repaired, or returned to the manufacturer for repair. The use of an air laboratory allows much better adjustment of all instruments, and no plant with pneumatic instruments should be without one.

contractors still had work to do, there was no delay in their turning over the plant to the city.

Obtaining accurate flow indications and totalization was a difficult problem at first. On the Midland branch of the Saginaw-Midland system it is necessary that the plant influent meters be accurate within 2 per cent of actual flow for billing purposes. Continued accuracy in this range has not been reached as yet in the new plant, but there still is hope. One of the reasons for many of the metering troubles was

that the pressure differentials for eight venturi meters were not the same as those for which the transmitters were adjusted. A cardinal rule for avoiding this type of problem is to make sure that the proper data are being used. If no data are on the meter, the manufacturer can supply the information from the serial number. Even with proper data, however, other meter problems may exist. The high-pressure differential taps on the Midland plant's influent venturi meters were directly under straightening veins, and it took many flow checks and much effort to correct this problem. In order to check the various meters in the plant, it was operated and the increase in water levels in the filtered-water reservoir were recorded. The volume of water arrived at by calculation was used to check the meter readings. This method is an ideal way to check influent meters, filter effluent meters, wash water meters, and plant effluent meters, provided that the plant may be so operated that only one variable is being checked at any one time.

After the new water plant was placed in continuous operation, it was planned to carry out extensive repair work in the old plant. Soon after the new plant was placed in operation, however, it became evident that some bottlenecks existed in the distribution system and that it would be difficult to pump at a rate of much more than 7 mgd. A detailed study of the system was made, therefore, and the bottlenecks are being corrected, although some involve right-of-way problems that will not be resolved until areas are plotted. Thus, the old plant was needed to provide proper pressure when the demand in the city went above 7 mgd, and renovations in the old plant were delayed for another year.

Sludge Blanket Troubles

Obtaining a good sludge blanket and, consequently, efficient chemical treatment in the solids contact softening tanks (Fig. 4) was a major problem at first. It took nearly 6 months to obtain a satisfactory blanket. On Jan. 19, 1959, the plant was put into continuous operation using lime for softening and alum as the coagulant. At this time of the year the water temperature is approximately 35°F and anything but ideal for starting up a chemical process. Both treatment tanks were put into operation, even though the average flow was only approximately 50 per cent of design flow. This meant that the upflow rate through the softening tanks was low, and, as it was found, after 2 months of failure to produce a sludge blanket, too low to suspend the sludge. Operation from two tanks with alum as the coagulant produced an alkalinity drop on the filters of 5–10 ppm during the best performance.

Operation of one treatment tank was suspended as soon as the lowness of the sludge settling rate was noted in the laboratory and correlated with the upflow rate in the tanks. After operation for 1½ months with all the flow passing through one tank, a slight blanket was formed. It was obvious, however, from the alkalinity drop of 4–5 ppm across the filters and from the turbidity of the water going to the filters, that operation was far from ideal.

At this point other coagulants were considered, even though the older plant had been treating the same water successfully for years with alum as the coagulant. The old plant employed split-treatment softening, however, whereas the new plant was designed for selective calcium bicarbonate softening in an upflow sludge blanket treatment

tank. As a satisfactory multiple stirrer for jar tests was not on hand, a new tester was ordered and various coagulant samples were requested from manufacturers. Salesmen of various coagulants were brought in and jar tests were made. A number of coagulants responded very well in the labo-

adequate in the jar tests, a sludge blanket still did not develop; indeed, the results seemed worse than with alum. Another load of iron was ordered, however, and this time enough ferric sulfate for several months was purchased. The concentration was then doubled over that found necessary in the labora-

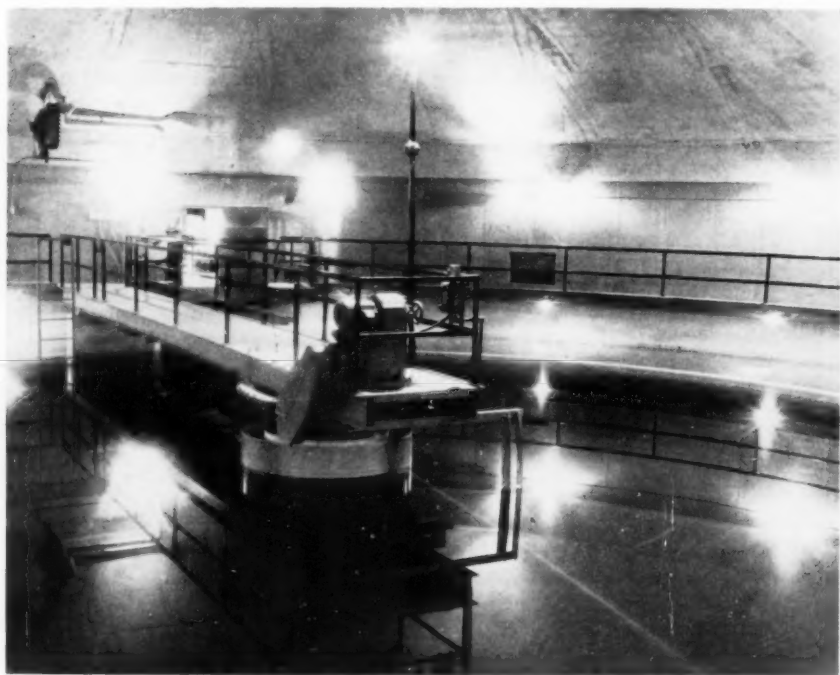


Fig. 4. Inside View of Multiple-Treatment Unit

The water in the foreground is the surface of the water undergoing pretreatment. After pretreatment, it overflows into the rapid sand filter surrounding the pretreatment tank.

ratory and it was decided to try ferric sulfate in a plant test, as the material performed very well in the jar tests and could be handled and fed in the same manner as alum. The cost was also nearly the same. Enough iron was ordered for 20 days, but after the iron was fed in the concentration found

tory and, in a few days, a sludge blanket began to form. In 10 days the turbidity of the water to the filters dropped from 10-20 ppm to less than 3 ppm. The alkalinity drop across the filter likewise decreased to approximately 1 ppm. It was found necessary to use 13.5 ppm of iron in plant opera-

tion to coagulate the calcium carbonate precipitate resulting from treatment of the water with 45 ppm CaO measured as plant lime. The raw water averages approximately 100 ppm in hardness and the plant tap averages 58 ppm. The alkalinity drop produced is 80 ppm to 30 ppm. The chemical cost for 1 mil gal of water has been approximately \$9. Some polyelectrolytes also

and totalize the plant influent flows. The feeder automatically feeds the fluoride within approximately ± 0.02 ppm of the concentration desired, regardless of flow and without manual adjustment of the controls. The only manual operation is to fill the day hopper with sodium silicofluoride.

Control of rate of flow through the filters is also ideal. To change the

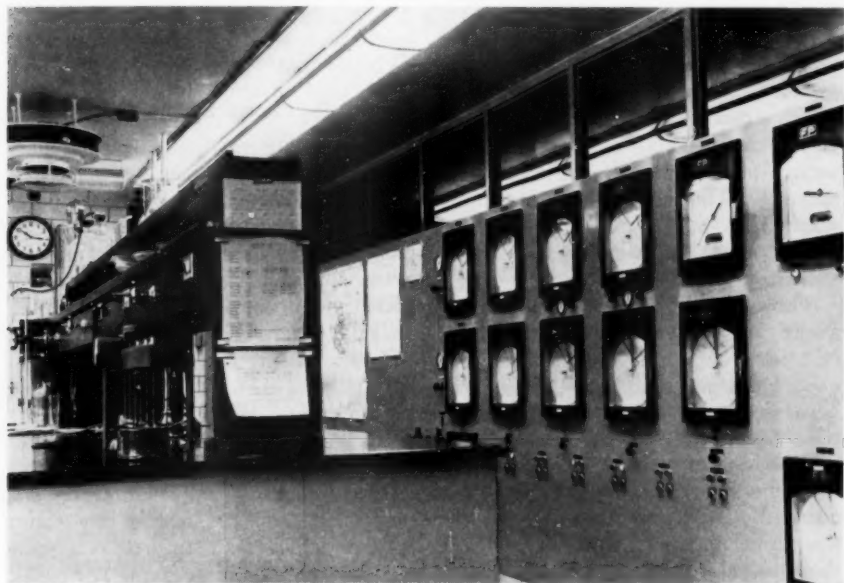


Fig. 5. Main Meter and Control Panel and Laboratory Bench

The charts are large enough to be read from the laboratory bench, thus making it possible for the operator to carry on routine testing and still keep an eye on the operation of the plant.

gave very promising results in the jar tests, and further work with them is planned.

Special Equipment

A number of operational functions in the plant are quite unique and merit special mention. The fluoride feeder is automatically paced by a pneumatic signal from instruments that measure

flow it is only necessary to turn a knob that controls a pointer and move the pointer to the desired flow as indicated on a chart. A controller then adjusts the filter effluent valve to the proper opening for the flow selected. Set point, rate of flow, and filter head loss are indicated on the same chart.

The controls for washing the filter are similar to the filter rate controls;

flow responds to the setting of a pointer to the desired filtration rate. The filters are easily washed and the operation is much more quickly and easily done than in the old plant. It is extremely easy to set up procedures when dealing with such "operationally" simple controls, so a manager's job is made much easier.

Two of the most useful of the instruments in the new plant are a telemeter that transmits and a receiver that records the water level in the elevated tank which rides on the distribution system. The operators depend fully on this instrument for information to interpret what pump should be on and anticipate what the demand will be for the day. The slope of line indicating water level in the tank gives a good indication of what is taking place in the system.

The automatic lime-conveying mechanism has proved very satisfactory, and, according to the operators, it is one of the most important differences between the old and new plants, as in the old plant the operators had to dump 80-lb sacks of pebble lime manually. The lime feeders and slakers are also automatically paced according to the flow going to the treatment tanks, and the units have been nearly as satisfactory as with the fluoride feeder. The paste lime slakers, however, have given considerable trouble. A number of breakdowns have occurred, presumably because oversized lime gets caught between the stationary and rotating mechanisms. Some trouble has also been experienced in maintaining the proper consistency for slaking. A number of modifications have been made in the slakers and operational problems have been reduced.

The laboratory room (Fig. 5) has the control panel along one wall and the test benches and equipment along

the other, which is an extremely functional arrangement. It allows the operator to carry on routine chemical and bacteriologic testing and still keep an eye on the operation of the plant. The charts are all large enough to be observed easily from the test bench. Sampling taps for raw water, filter effluent, and plant effluent are left running continuously to insure fresh samples and easy sampling. The operators are most satisfied with the arrangement and believe that it leaves little to be desired.

Public Relations Efforts

Good public relations are an important consideration when a new plant is being constructed and put into operation. It is an ideal time to make the public aware of the water system and what the bond issues they approved have bought. In Midland, a number of articles, accompanied by pictures of the new plant, appeared in the local papers, and an open house was held at the plant. Many groups of visitors from various organizations and other cities have toured the plant. A brochure containing information on the new plant and the rest of the water system, which has been used as a guide for plant tours and in giving the public information, has proved to be a valuable public relations tool.

The people who have been associated with the new Midland plant are extremely proud of it. There are some items of design that could be improved for more satisfactory operation, but these are minor and more than offset by other desirable features. The consulting engineers and contractors have done a very commendable job. The new plant is not only unique in design; it is aesthetically pleasing, functional, and an object of pride to the community.

Improved Entry to Transfer Line in Primary Sedimentation Basin

A. Adler Hirsch

*A contribution to the Journal by A. Adler Hirsch, Water Purification
Supt., Dept. of Water & Sewerage, Shreveport, La.*

AT the McNeil Street water plant in Shreveport, La., water treated with alum is settled in the east basin, then limed for pH correction before passing to the west basin for contact time and further subsidence before filtration. Both sedimentation basins are provided with a set of orifice walls, forming inlet and outlet boxes. Effluent from the east basin formerly flowed through a 20-in. line connected behind the orifice boxes. In 1939, in order to hasten the rate of flow across the basins, a 16-in. line was added on the basin side of the orifice walls (Fig. 1).

Disadvantages of Additional Line

Although the 16-in. line ("equalizing line") facilitated the passage of water, it also permitted a considerable amount of floc to be carried over from the east basin, because the floc was not blocked by the orifice wall. Whenever the settled water was clear enough for observation of the opening of the 16-in. pipe, a stream of alum floc could generally be seen funneling into it. This floc was partly disintegrated and redissolved at the higher pH following liming, increasing the concentration of dissolved aluminum, reducing the clarity of the applied water on the filters, and providing materials for after-precipitation in the distribution system

as the pH dropped with time. Furthermore, failure to mix the lime suspension completely with the entire throughput of water at the effluent corner of the east basin made the aluminum resolution even worse by over-alkalizing that portion of the flow which the 20-in. line carried. Water from the 16-in. line was mixed in with this alkalized fraction beyond the orifice wall of the west basin.

Another, but minor, disadvantage in the construction of the 16-in. equalizing line was the protruding ends of the pipe, especially on the entrance side. This caused a Borda mouthpiece effect by increasing turbulence and friction loss at the entrance section. On the exit end, the turbulence was desirable, for it provided a better mixture of the lime hydrate particles within the water.

Extension of Transfer Line

The problem, then, was one of re-locating the point of entry of the 16-in. transfer line—so as to prevent the massive draft of floc and the delayed dispersion of lime—and streamlining the fitting selected to avoid an increase in loss of head between the basins. From the layout it was evident that a standard 90-deg bend, with its entrance open to the water inside the

orifice box of the east basin, would suffice. A double-bell fitting was selected so that one end could be pour-jointed to the protruding end of the transfer line inside the east basin wall, and the other end concreted and keyed into the orifice wall. On the entrance end, the bell was streamlined by means of a filler material.

double-bell 90-deg elbow was used in place of an integral trumpet-mouth bell because of its availability and lower cost.

Several filter materials were considered for shaping the entrant bell, such as lead, solder, cement mortar, sulfur jointing compound, plaster of paris, and plastic base putty. The last

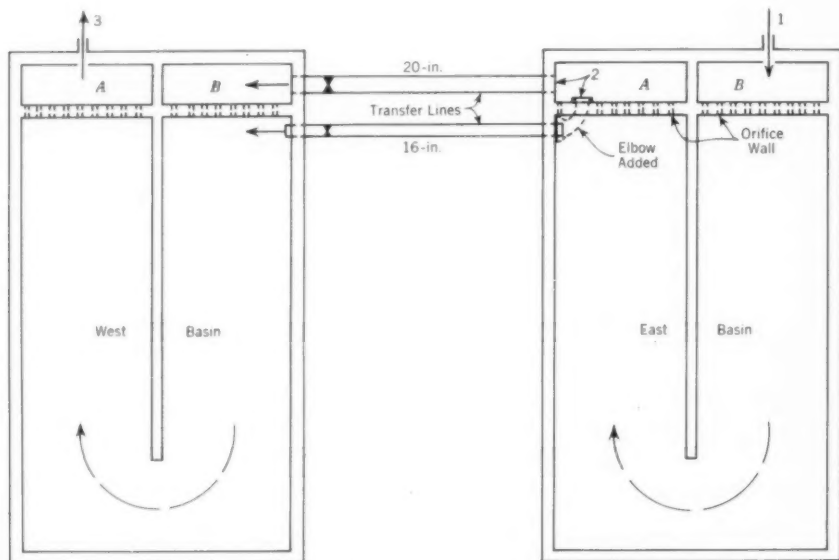


Fig. 1. Top View of Sedimentation Basins at Shreveport

At Point 1, water enters from the mixing basin; at 2, lime is added; at 3, water leaves the basin for the filters. A and B represent the outlet and inlet boxes, respectively. The curved arrows show the course of flow within the basins. The overall dimensions of each basin are: 15.5 ft deep, 90.25 ft wide, and 167.5 ft long. Raw-water pumpage rates are 10.5 mgd and 17 mgd.

The approximate values shown in Table 1 indicate that the added head loss caused by the elbow was almost cancelled by replacing the Borda-type mouthpiece with a streamlined flare. Thus, the added bend did not impair the hydraulics of the pipe. The

was selected because of its hardness, toughness, tenacity, waterproofness, permanency, and reasonable cost. A polyester putty with glass fiber reinforcing, which could be hardened by a small amount of liquid catalyst mixed immediately before application, was the

material chosen. This preparation* has been widely used for repairing dents and holes in automobile bodies; it has almost supplanted solder for this purpose. The waterproof quality of these glass-fibered resins is known from their use on boat hulls.

The rounding of the entrant bell was done by first chipping both exterior and interior edges of the hub with a blacksmith's cold cutter and grinding off the surfaces into a smooth curve. The bell socket was then lined with expanded metal lath, held by $\frac{1}{4}$ -in. screws to the cast-iron sides. The lath provided anchorage for the putty, in addition to the adhesive qualities of the putty itself. At this stage, the inside of the bell and the wire lath were sand-blasted to prepare for the application



Fig. 2. Application of Filler to Bell End of Elbow

Glass-fibered polyester resin putty was applied over, and pressed into, an expanded metal lath screwed to the cast-iron sides.

of the glass-fibered polyester resin filler. Next, the catalyzed putty was mixed in small amounts and pressed well into the socket (Fig. 2). After hardening, the surface of the filler was smoothed to the desired contour with a thin metal punch-out rasp. Finally, the finished bell was coated with rust-resistant paint.

Installation was accomplished by lowering the fitting into position by a chain hooked to the boom of a back hoe. Support from the projecting wall stub was first obtained by pouring the joint with sulfur jointing compound. The bell was then concreted into a hole cut in the orifice wall, using quick-setting cement. Figure 3 shows the finished job. On the next day, the basin was filled with water; a day later, it was placed in service. The cost of the elbow and the materials used for streamlining was about \$162. The elbow was installed by a maintenance crew of the Shreveport Department of Water and Sewerage.

Results

Several operating results were immediately observed after use of the

TABLE 1

Friction Loss in 16-in. Transfer Pipe Before and After Addition of Stream-Mouth Elbow

Item	Equivalent Length of Straight Pipe ft
Without Elbow	
Borda entrance	38
Run of pipe	25
Sudden enlargement	37
<i>Total</i>	100
With Elbow	
Contoured entrance	2
Elbow	38
Run of pipe	25
Sudden enlargement	37
<i>Total</i>	102

* Bond-O, made by Jaycee Chemical Corp., Northford, Conn.

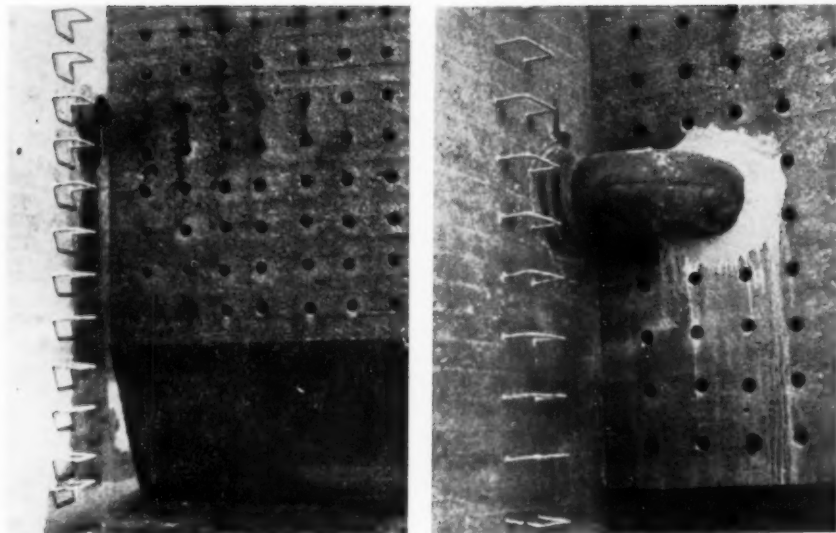


Fig. 3. East Basin, Before and After Installation of Elbow

The photograph on the left shows the protruding end of the 16-in. cast-iron transfer line outside the effluent orifice box. On the right, the installation of the 90-deg bend has been completed; settled water is now drawn from inside the orifice box.

elbow extension of the 16-in. transfer line to the orifice box. A whirlpool was formed at the east basin outlet from the concentration of the complete flow to the corner of the outlet box; the result was a better dispersal of the line suspension than before. No appreciable change was noted in the relative levels of the two sedimentation basins.

Effluent from the west basin to the filters was remarkably improved; the turbidity of the water on top of the filters was of tap range. The sand surface was sharply visible, whereas it was hazy before. Although the alum dosage was greatly reduced, filter runs increased as much as 50 per cent. Washings are now made on a 72-96-hr schedule, instead of the former 48-72-hr schedule. Wash water

drainings now clear up earlier in a wash, and the wash-gutter stream at the termination of a wash is cleaner than it ever had been prior to the installation.

The amount of coagulant feed has been radically reduced; the alum feeder now operates with a scale setting lower than ever before. Alum dosage is approximately 40 per cent of that used before the installation. Lime dosage has been decreased in accordance with the amount of alum it is required to balance. In view of these short-term results, annual savings in chemical costs are expected to be approximately \$10,000.

Summary

An extension of the entrance of an auxiliary transfer line from an un-

shielded position to a screened position behind the orifice wall at the effluent end of the east basin almost eliminated carryover of alum floc to the west basin, thus greatly improving the clarity of applied water on the filters. Better conditions for lime dispersion were also provided by the creation of

a whirlpool where the suspension was added.

A method of streamlining bell ends of pipe with glass-fibered polyester resin filler was successful in reducing hydraulic losses at the entrance of the pipe. Significant savings in alum and lime are indicated.

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Cumulative Distribution Method for Evaluating Series of Fluoride Ion Test Results

Floyd B. Taylor

A contribution to the Journal by Floyd B. Taylor, San. Engr. Director, General Eng. Program, Div. of Eng. Services, Bureau of State Services, USPHS, Washington, D.C.

SPITZ, Taylor, and Harris¹ showed that results of fluoride ion tests on samples taken from public water supply distribution systems could vary widely and fall significantly below optimum values for the area concerned. They predicted also that maximum benefits in dental caries prevention would not be achieved unless optimum fluoride concentrations were consistently maintained. That this was a true assumption was demonstrated by Chrietberg and Lewis² in their study of 8,272 school children in De Kalb County, Ga.

Visual inspection of a series of fluoride ion test results does not always reveal the true course of the fluoridation process. For example, in reviewing a column of many figures, the small values may appear to be insignificant when seen together with a greater number of larger values. After systematic arrangement and analysis of the total data, however, it is sometimes found that the small values have depressed the mean to a point where corrective action is imperative. A systematic analysis of a series of fluoride ion test results at regular intervals is also recommended to detect any trend of mean values that may be significant.

In an analysis of fluoride ion test results from a public water supply,³ the statistical method of cumulative distri-

bution was found to be a simple and useful tool. As this method is not generally known to water utility operators and public health engineers, a demonstration of the method, as it can be applied to fluoridation, may be helpful. The fluoride ion test data are from actual situations.

Definitions

The statistical terms used in this article are defined as follows:

Cumulative distribution: the successive total number of samples with a fluoride ion concentration up to and including a given value in the series. It is expressed as a percentage.

Median: the fluoride ion value so chosen in a series that half the sample test results are greater than, and half less than, this value.

Mean: the arithmetic average fluoride ion value of a series.

Range: the difference in fluoride ion concentration between maximum and minimum values in a series.

Standard deviation: a measure of variation about a mean. When considered together with the mean, it is a central range containing about two-thirds the test results in the series—that is, the mean fluoride ion concentration plus and minus the standard deviation is the range within which about

two-thirds of the test results of the series fall.

Procedure

1. Gather a series of test results over a period of a few weeks; a period not exceeding 3 months is recommended. The raw data may be similar to the following (values represent fluoride ion content, in parts per million, in distribution system samples):

0.2	1.0	1.2	1.0	1.0	1.0	1.0	0.6	1.2	0.6
0.8	1.0	1.2	0.8	1.0	1.0	0.2	0.7	1.2	0.4
0.3	0.2	1.0	0.3	0.8	1.2	1.0	1.0	0.3	0.5
0.8	1.0	1.1	0.6	0.8	0.4	0.8	1.2	0.6	0.6
0.3	1.0	1.0	0.5	0.9	0.9	0.8	1.0	0.8	0.3
0.4	0.5	1.1	0.6	0.9	0.9	0.8	1.1	1.2	0.6
0.5	1.0	1.0	0.6	1.0	1.1	0.8	1.1	0.8	1.2
0.9	1.0	1.1	0.8	1.2	1.1	0.8	1.1	0.8	0.8
1.0	1.1	1.0	0.9	1.0	0.4	0.9	1.1	1.2	0.8
0.6	1.0	1.0	0.9	1.0	0.5	0.9	1.1	1.2	0.8
0.8	1.0	1.1	0.9	1.2	1.0	0.9	1.0	0.4	0.9
0.9	1.1	1.2	1.0	1.0	1.0	1.2	1.2	0.5	0.9
1.0	1.0	1.1	1.2	1.0	1.0	1.2	1.2	0.9	0.8

2. Construct a table with columns and headings similar to those in Table 1.

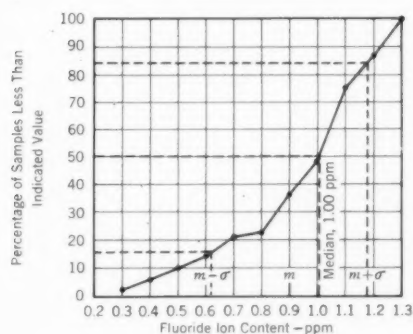


Fig. 1. Cumulative Distribution of 130 Fluoride Ion Test Results

The letter *m* represents the mean, 0.9 ppm; σ represents the standard deviation of 0.28 ppm.

TABLE 1

Suggested Arrangement of Data—
130 Fluoride Ion Test Results*

(Column 1)	(Column 2)	(Column 3)	(Column 4)
Fluoride Ion Content ppm	No. of Samples	Cumulative No. of Samples	Cumulative No. of Samples %
0.2	3	3	2.3
0.3	5	8	6.2
0.4	5	13	10.0
0.5	6	19	14.6
0.6	9	28	21.6
0.7	1	29	22.3
0.8	19	48	36.9
0.9	15	63	48.5
1.0	35	98	75.5
1.1	14	112	86.2
1.2	18	130	100.0

* The identification of each column, shown in parentheses, is for purposes of discussion.

3. Determine the range of test values covered by the raw data. In Column 1 of the table, cover the range in equal increments. Increments of 0.1 ppm are recommended when the data have one significant decimal place; 0.05 ppm, when two significant decimal places are found.

4. In Column 2 of the table, enter opposite each value in Column 1 the number of samples that tested at the value. For example, in the raw data, it is found that three samples tested at 0.2 ppm, five at 0.3 ppm, and so on.

5. In Column 3 of the table, cumulatively add the figures in Column 2. The last entry must equal the total number of samples, and thus provides a check on the arithmetic.

6. In Column 4, enter opposite each number in Column 3 the percentage that number is of the total number of samples. Thus, 3 samples are 2.3 per cent of 130, 29 samples are 22.3 per cent, and so on. The last figure must be 100 per cent.

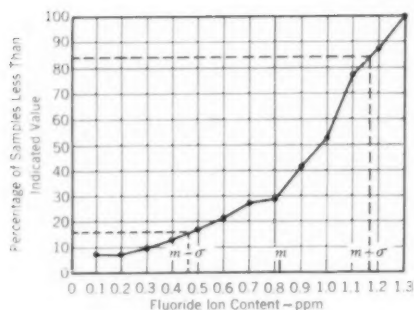


Fig. 2. Cumulative Distribution of 141 Fluoride Ion Test Results

The letter m represents the mean, 0.815 ppm; σ represents the standard deviation of 0.35 ppm.

7. On a sheet of arithmetic graph paper, construct, to a convenient scale, two axes. Call the vertical scale percentage of samples less than the indicated value; call the horizontal scale fluoride ion content in parts per million. The horizontal scale must cover the range and one step above the upper limit of the range (Fig. 1).

8. Plot the data in Column 4 of the table against the data in Column 1, and connect the points by straight lines. Plot the points one increment above the value at which the percentage is shown. For example, plot 2.3 per cent opposite 0.3 ppm, for actually 2.3 per cent of the samples are less than 0.3 ppm in fluoride ion content.

9. From the 16 per cent and 84 per cent points on the vertical scale, intersect the plotted curve with horizontal dotted lines, and project them downward vertically to intersect the horizontal scale. On this scale, bisect the distance between the two points and determine the value of the new point. This is a reasonable approximation of the mean value of the series. In the

example given (Fig. 1), the mean value is 0.9 ppm.

10. Determine the value, in parts per million from the horizontal scale, of the distance from the mean point to either of the points from which it was found. This value—0.28 ppm, in the example cited—is a reasonable approximation of the standard deviation of the series.

If it is desired to find the median of the series, draw a horizontal dotted line from the 50 per cent point on the vertical scale to the plotted line; then draw a vertical dotted line to the horizontal scale. The point at which the vertical line intersects the horizontal scale is the median value of the series.

Interpretation of Results

Arroe,⁴ Spitz,¹ and Taylor³ showed that it is possible to maintain fluoride ion values so that the mean of a series of test results varies very little from the desired optimum value, and so that the test results cluster closely about the mean value. When this occurs,

TABLE 2
Suggested Arrangement of Data—
141 Fluoride Ion Test Results

Fluoride Ion Content ppm	No. of Samples	Cumulative No. of Samples	Cumulative No. of Samples %
0.0	11	11	7.81
0.1	0	11	7.81
0.2	3	14	9.94
0.3	5	19	13.49
0.4	5	24	17.04
0.5	6	30	21.30
0.6	9	39	27.69
0.7	1	40	28.40
0.8	19	59	41.89
0.9	15	74	52.54
1.0	35	109	77.39
1.1	14	123	87.33
1.2	18	141	100.00

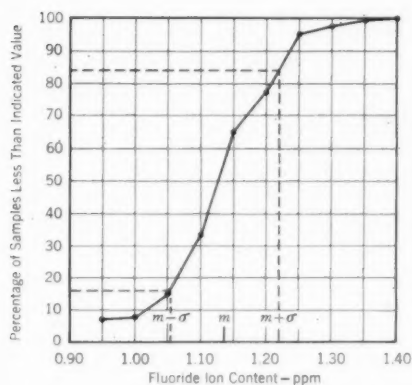


Fig. 3. Cumulative Distribution of 432 Fluoride Ion Test Results

The letter *m* represents the mean, 1.135 ppm; σ represents the standard deviation of 0.083 ppm.

the standard deviation is found to be only a few thousandths of a part per million. More important, when the means of series of test results become and remain little or no different from the optimum value, and when the standard deviation becomes and remains small, optimum caries reduction may be anticipated.

In the locality from which the series of test results cited above was gathered, the optimum fluoride ion value and the value that the water plant operators sought to maintain were both 1.0 ppm. It is seen (Fig. 1) that the mean value of the series examined was 0.9 ppm—0.1 ppm less than the optimum—and, more important, the large standard deviation of 0.28 ppm showed a wide scattering of results. If these conditions prevailed over an extended period, there would, undoubtedly, be less of a reduction of caries in the area than should be expected. This may be further understood by comparing the above data first with a series that was

less satisfactory, and then with one that showed an excellent fluoridation experience.

Table 2 and Fig. 2 depict a series in which, by the above method, the mean was found to be 0.815 ppm and the standard deviation 0.35 ppm. The optimum value sought to be maintained was 1.0 ppm.

In contrast to both the above series are the results of analyzing 432 test results from another supply. The optimum value for the area was 1.1 ppm. The cumulative distribution analysis (Table 3 and Fig. 3) showed a mean value of 1.135 ppm and a standard deviation of only 0.083 ppm.

Summary

The cumulative distribution method for analyzing series of fluoride ion test results has been found to be a simple and useful method for determining the true course of the fluoridation process. Optimum results of fluoridation, in terms of caries reductions, can be anticipated only when mean fluoride ion values are consistently maintained at the optimum value for the area concerned.

TABLE 3
Suggested Arrangement of Data—
432 Fluoride Ion Test Results

Fluoride Ion Content ppm	No. of Samples	Cumulative No. of Samples	Cumulative No. of Samples %
0.90	27	27	6.25
0.95	4	31	7.18
1.00	35	66	15.28
1.05	79	145	33.56
1.10	138	283	65.51
1.15	52	335	77.55
1.20	79	414	95.83
1.25	9	423	97.92
1.30	8	431	99.77
1.35	1	432	100.00

A low standard deviation indicates a compactness of the daily test result values about the mean, which should lead to a more satisfactory fluoridation experience.

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Survey of Phosphate and ABS Concentrations in Illinois Streams

—James J. Morgan and Richard S. Engelbrecht—

A contribution to the Journal by James J. Morgan, Instructor, and Richard S. Engelbrecht, Assoc. Prof., both of the Dept. of Civ. Eng., Univ. of Illinois, Urbana, Ill.

THE rapid increase in the use of synthetic detergents during the past decade has undoubtedly led to the presence of greater quantities of synthetic detergent compounds in sewage effluents and, as a consequence, in certain surface water supplies. Questions have been raised concerning the persistence of these substances in natural waters and their possible effects on water treatment processes.

Household synthetic detergents generally contain, as their major components, alkyl benzene sulfonate (ABS) and complex phosphate salts, usually sodium tripolyphosphate and tetrasodium pyrophosphate. Recent research conducted at the sanitary engineering laboratory of the University of Illinois has investigated the prevailing levels of phosphate compounds and ABS in Illinois surface waters and their relation to other water quality data, the degradation of condensed phosphate compounds in natural waters, and the effect of various phosphate compounds on the coagulation and sedimentation processes of water treatment.

Previous papers^{1,2} have reported results of certain other aspects of this research. This article presents the data on ortho- and condensed phosphates, ABS, and water quality which were obtained as a result of the survey of Illinois surface waters made during the

period 1955-57, in which 204 surface water samples were collected and analyzed.

The survey of Illinois surface waters consisted of four parts:

1. Sampling of seven lakes and reservoirs to determine phosphate and ABS levels in water supplies free of significant domestic pollution

2. Sampling at 26 locations on streams used as sources of water supply and distributed throughout the major Illinois river basins (These were believed to be receiving significant amounts of treated and untreated domestic wastes.)

3. Continued sampling over a period of 8 months at selected locations in the Kaskaskia River Basin, the second largest basin in Illinois, in order to define phosphate and ABS levels existing under known conditions of rainfall, stream discharge, sewage discharge, and agricultural drainage

4. Continued sampling over a 2-month period at six locations on three streams in the DuPage County watershed area, in order to investigate instances of stream pollution reportedly stemming from synthetic detergents (These streams do not serve as water supply sources.).

Figure 1 shows the location of all sampling stations involved in the survey.

The Kaskaskia River was chosen for an intensive survey because its location was convenient to the laboratory, because of the considerable number of rain-gaging and stream discharge-gaging stations throughout the basin, and because of the availability of hydrologic and land use data for the

Rainfall and Stream Discharge

In general, the years 1955 and 1956 were drier years than the long-term average for Illinois. Rainfall during 1955 was 6 per cent below normal, and during 1956 it was approximately 23 per cent below normal. Monthly precipitation at three rain gages are shown



Fig. 1. Sampling Locations in Survey

The map shows all streams included in the survey, as well as the locations of sampling stations.

watershed area. Stream sampling stations were selected at Bondville, Ficklin, Shelbyville, Vandalia, Carlyle, and New Athens on the Kaskaskia River (Fig. 1). A total of 125 stream samples were collected during the Kaskaskia survey, which lasted from April to December 1956.

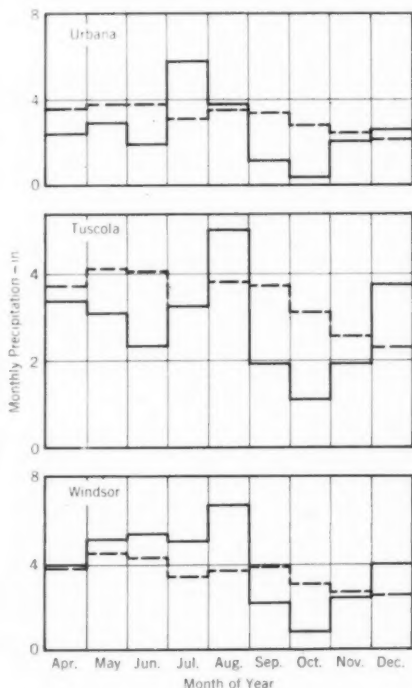


Fig. 2. Monthly Precipitation at Three Kaskaskia Basin Gaging Stations

The solid curves represent monthly mean precipitation for 1956; dashed curves represent the normal precipitation.

in Fig. 2. These gages are in proximity to the Bondville, Ficklin, and Shelbyville stream-sampling stations in the upper Kaskaskia Basin.

The average streamflow discharge for the period of record at Shelbyville

on the Kaskaskia was 0.853 cfs/sq mi. Average discharge for the 1955-56 water year was 0.453 cfs/sq mi, or about half of the long-term average.

More important is the relationship of stream discharge at the time of sampling to the long-term flow record. This can be indicated by the relation of the distribution of flows at the time of sampling to the distribution of average daily flows established from long-term records by the USGS. Figure 3 shows a comparison of these distributions for Shelbyville, Ill. The data are plotted on a logarithmic probability grid, following a method used by Mitchell.³

Handling of Samples

All of the water samples were collected in polyethylene bottles and, after the temperature was recorded, were immediately iced for transportation to the laboratory. A sample was also collected for dissolved oxygen and fixed in the field, so that the titration could be performed later. Each water sample was analyzed at the laboratory for ortho- and condensed phosphate, ABS, turbidity, alkalinity, hardness, pH, and dissolved oxygen, within 12-18 hr of the time of collection.

Analytical Methods

The analyses for orthophosphates and hydrolyzable condensed phosphate were made by a modified extraction and hydrolysis procedure originally proposed by Martin and Doty.⁴ This modified procedure, in which phosphomolybdate is extracted with a benzene-isobutyl alcohol mixture and reduced with stannous chloride, has been published as an Association of American Soap and Glycerine Producers (AASGP) committee report.⁵ Orthophosphate P_2O_5 was obtained by running the colorimetric extraction deter-

mination directly on the water sample. Hydrolyzable P_2O_5 was determined in a similar manner after acid hydrolysis. In determinations of hydrolyzable phosphate, it has been observed that the acid hydrolysis step includes a portion of the phosphorus from organic compounds with condensed phosphate groups.⁶ Therefore, after the previously determined orthophosphate value has been subtracted, the hydrolyzable-phosphate concentration is equal to or greater than the true value for inorganic condensed-phosphate.^{2, 6} For this reason, the hydrolyzable condensed

TABLE 1
Phosphate and ABS Concentrations in Illinois
Lakes and Reservoirs, 1956

Source	P_2O_5 —ppm		Apparent ABS ppm
	Ortho + MIC	MIC	
Springfield	0.000	0.000	0.000
Kincaid	0.000	0.000	0.016
Decatur	0.032	0.016	0.008
Paris	0.044	0.018	0.010
Danville	0.113	0.022	0.016
	0.195	0.087	0.006
Salem	0.115	0.049	0.011
Bloomington	0.226	0.208	0.000
Mean	0.091	0.050	0.008

P_2O_5 is referred to as the maximum inorganic condensed P_2O_5 (abbreviated MIC P_2O_5). For clarity, it should be pointed out that what has previously been referred to as "total" P_2O_5 is expressed as ortho- P_2O_5 plus MIC P_2O_5 in this article.

The method of analytical determination for ABS used in this study was obtained from the research department of a large chemical company and was a modification of the original procedure proposed by Degens and others.⁶ A slight modification of the method

TABLE 2

General Survey of Phosphate and ABS Concentrations in Illinois Streams, 1956

Sample Source	Date	P ₂ O ₅		Apparent ABS	Ratio of Flow to Mean 1956 Flow
		Ortho + MIC	MIC		
		Concentration—ppm			
Embarrass R. Oakland	Feb. 13	0.025	0.012	0.027	1.6
Charleston	Feb. 12	0.076	0.043	0.192	1.4
Newton	Feb. 13	0.109	0.033	0.046	1.6
Illinois R. Grafton	Mar. 20	1.551	1.010	0.119	0.6
Kankakee R. Kankakee	Feb. 1	0.085	0.012	0.021	0.5
Kaskaskia R. Vandalia	Feb. 20	0.706	0.372	0.042	3.1
Carlyle	Feb. 20	0.708	0.337	0.056	3.8
New Athens	Feb. 21	0.788	0.408	0.072	3.4
Evansville	Feb. 21	0.786	0.319	0.053	3.4
Silver Creek Mascoutah	Feb. 20	1.560	0.976	0.000	
Freeburg	Feb. 20	3.402	0.503	0.352	
Little Vermilion R. Georgetown	Jan. 31	0.082	0.000	0.021	
Little Wabash R. Flora	Feb. 11	0.113	0.052	0.000	1.7
Clay City	Feb. 11	0.113	0.055	0.160	1.7
Fairfield	Feb. 13	0.148	0.077	0.002	1.4
Mississippi R. Dallas	Apr. 14	0.338	0.237	0.122	2.2
Nauvoo	Apr. 19			0.075	2.1
Hamilton	Apr. 19	0.400	0.243	0.026	2.1
Warsaw	Apr. 19	0.603	0.376	0.101	2.1
Quincy	Apr. 20	0.654	0.344	0.098	2.3
Alton	Apr. 21	0.726	0.105	0.328	2.3
E. St. Louis	Feb. 4	0.435	0.114	0.938	0.6
E. St. Louis	Feb. 21	0.715	0.128	0.064	0.6
Chester	Feb. 21	1.352	0.788	0.016	0.6
Vermilion R. Pontiac	Feb. 1	0.073	0.011	0.054	0.1
Streator	Feb. 1			0.189	0.1
Wabash R. Mt. Carmel	Feb. 13	0.149	0.054	0.040	1.6
Mean		0.629	0.264	0.119	

used has been reported by Fairing and Short.⁷ The method is dependent upon the extraction of methylene blue salts of alkyl and aryl sulfates and sulfonates from an aqueous solution by chloroform.

This method, like all dye methods, is subject to a variety of errors.⁷ These errors may be caused by either organic or inorganic compounds and may produce either negative or positive interferences. In determining ABS in

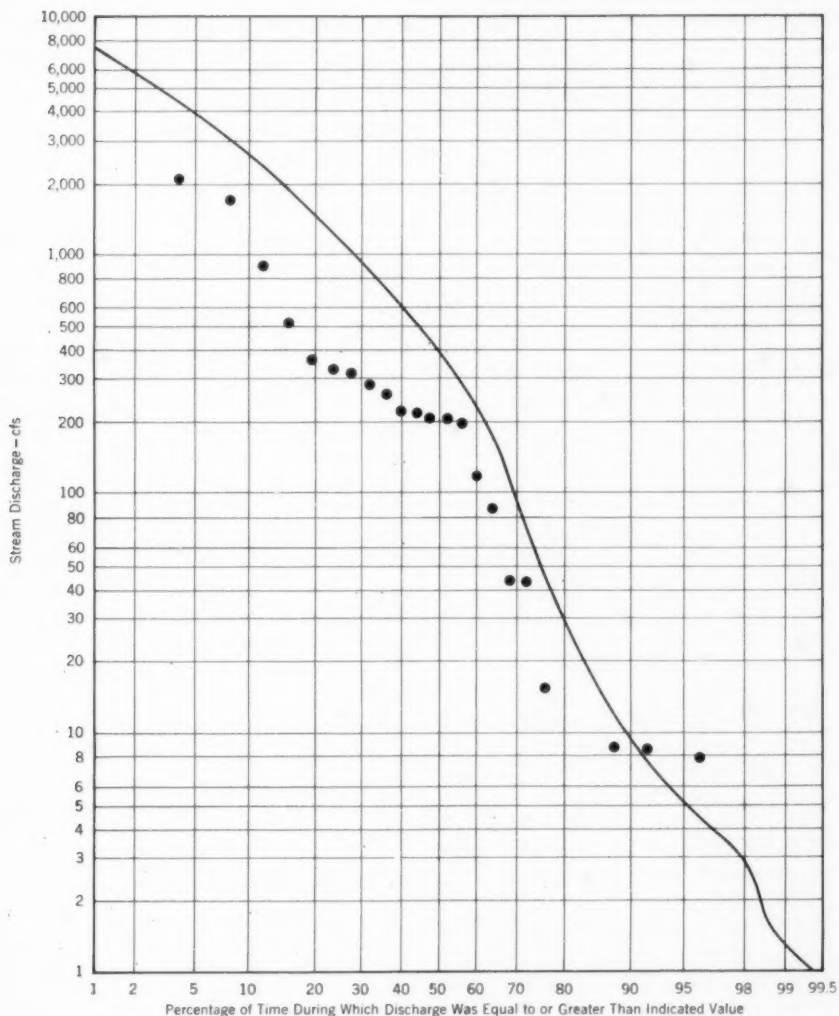


Fig. 3. Stream Discharge for Kaskaskia River at Shelbyville, Ill.

Plotted data and the curve represent daily discharge for 1956 and for the period of record, respectively.

water, it has been reported that the positive interferences are much more significant.⁸ Thus, the determination of ABS in surface waters by the method used throughout this study yields results that are, in all probability, greater than the true values. For this reason, the ABS data have

Lakes and Reservoirs

The analytical results for phosphate and apparent ABS in lakes and reservoirs are presented in Table 1. Condensed P_2O_5 (MIC) ranged from 0.000 to 0.208 ppm in the eight samples. Values of apparent ABS were low, ranging from 0.000 to 0.016 ppm. This was as expected for sources relatively free of domestic pollution.

General Stream Survey

Data resulting from the survey of major Illinois drainage basins are presented in Table 2. The ratio of stream discharge for the date of sampling to the mean 1956 discharge (based upon discharge records at the nearest USGS gaging station) is also given. Mean total P_2O_5 was 0.629 ppm, and mean MIC P_2O_5 was approximately half that amount, or 0.264 ppm. Mean apparent ABS was 0.119 ppm. The highest total P_2O_5 value, 3.402 ppm, was found at Freeburg, on Silver Creek. Silver Creek is a small stream receiving domestic waste discharged from a military installation. The highest value of apparent ABS, 0.938 ppm, was found at East St. Louis on the Mississippi. This high value may be the result of the presence of either an industrial discharge or interferences that affected the analytical determination of ABS. It is significant that the same sampling location gave an apparent ABS value of 0.064 ppm 2 weeks later.

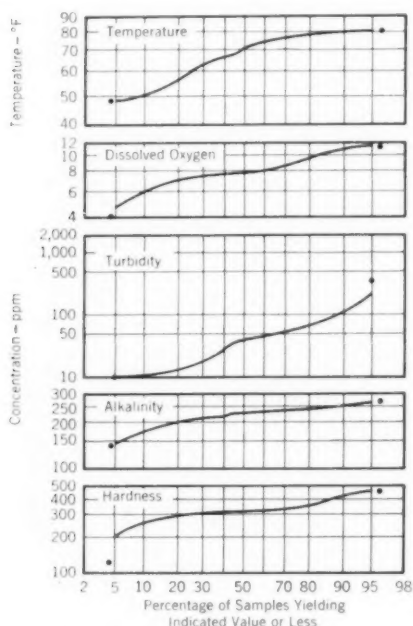


Fig. 4. Water Quality Data for the Kaskaskia River at Shelbyville, 1956

Each curve represents results for 20-25 samples.

been referred to as apparent ABS concentrations.

With the exception of turbidity measurements, which were made using either a Jackson candle or Hellige turbidimeter, all other determinations were made in accordance with the techniques described in *Standard Methods*.⁹

Kaskaskia River Survey

Drainage areas and tributary sewer populations for each Kaskaskia sampling station are given in Table 3. Distribution curves of data for temperature, dissolved oxygen, turbidity, alkalinity, and hardness at Shelbyville

are shown in Fig. 4. The data are summarized on a logarithmic probability grid, the abscissa expressing the percentage of samples having a value equal to or less than the indicated value of the ordinate. Each curve represents the results for 20-25 samples.

Figure 5 summarizes the variation in MIC P_2O_5 , ortho- plus MIC P_2O_5 , and apparent ABS found in samples collected at Bondville, Ficklin, and Shelbyville, respectively. Curves of best fit have been drawn only between the 10 per cent and 90 per cent values, because of the relatively few samples from each station. Of the Shelbyville samples, 90 per cent contained less than 0.8 ppm MIC P_2O_5 and less than 1.2 ppm ortho- plus MIC P_2O_5 , and the apparent ABS was less than 0.2 ppm. The 50 per cent, or median, values for MIC P_2O_5 , ortho- plus MIC P_2O_5 , and apparent ABS were approximately 0.12 ppm, 0.45 ppm, and 0.09 ppm, respectively.

Figure 6 summarizes the data for MIC P_2O_5 , total MIC P_2O_5 , and apparent ABS resulting from analyses of 125 samples collected from the Kaskaskia River during 1956. Of all samples, 90 per cent contained less than

TABLE 4

*Letter Code to DuPage Watershed
Area Stations*

Station	Symbol
Salt Creek	
Station 1	G
Station 2	H
East Branch DuPage	
Station 1	J
Station 2	K
West Branch DuPage	L
Tributary Creek to West Branch	M

0.42 ppm MIC P_2O_5 , less than 0.84 ppm ortho- plus MIC P_2O_5 , and less than 0.18 ppm apparent ABS.

A comprehensive view of water quality data for the Kaskaskia River Basin is presented in Fig. 7. Mean, low, and high values of the data for each station and an overall summary for all stations are shown. Mean values were: temperature, 65°F; hardness, 300 ppm $CaCO_3$; alkalinity, 225 ppm $CaCO_3$; turbidity, 100 ppm; apparent ABS, 0.08 ppm; MIC P_2O_5 , 0.20 ppm; and ortho- plus MIC P_2O_5 , 0.40 ppm.

It has been reported² that significant quantities of phosphate, in both ortho and condensed forms, are contributed to streams by drainage from agricultural land. Using the results of turbidity and phosphate analyses in conjunction with USGS stream discharge data for dates of sampling, calculations of quantities of turbidity and ortho-plus MIC P_2O_5 were made for three Kaskaskia stations and plotted on a logarithmic grid. Figure 8 shows the resulting correlation between turbidity and phosphate. Lines of best fit were obtained according to the method of least-squares. The 95 per cent confidence limits are also shown for the data of each station. These results tend to

TABLE 3

*Kaskaskia River Sampling Stations and
Letter Code*

Station	Drainage Area sq mi	Tributary Population	Symbol
Bondville	12	0	A
Ficklin	125	820	B
Shelbyville	1,030	6,670	C
Vandalia	1,980	12,850	D
Carlyle	2,680	18,320	E
New Athens	5,220	90,240	F

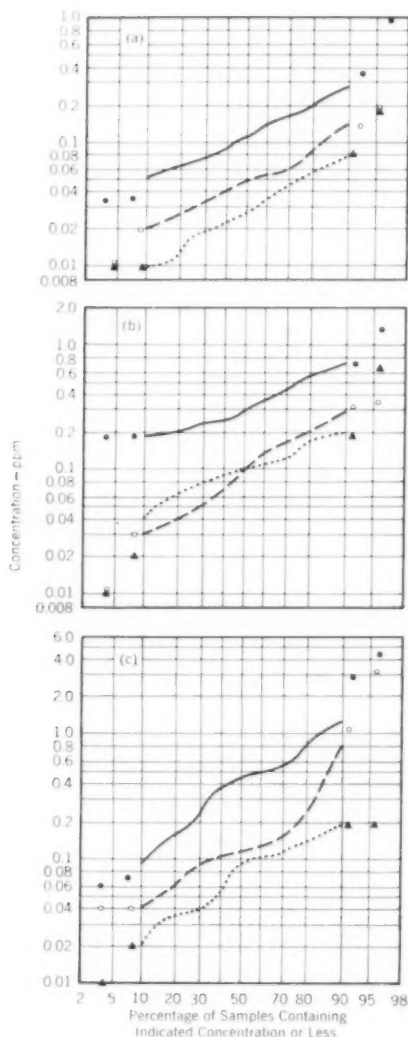


Fig. 5. Phosphate and ABS Concentrations at Three Locations on the Kaskaskia River

Parts a, b, and c give data for Bondville, Ficklin, and Shelbyville, respectively. The solid, dashed, and dotted curves are for ortho- plus MIC P_2O_5 , MIC P_2O_5 , and ABS, respectively.

support the importance of land drainage in relation to stream phosphates.

DuPage Watershed Area

The results of the DuPage survey are summarized in Fig. 9, in which mean, low, and high values of the various analyses are indicated. Stream sampling locations are identified in Table 4. In general, Salt Creek, the East DuPage River, and the West DuPage River were severely polluted during the period of this survey, June–August 1956. Low dissolved-oxygen levels existed at Station 1 on Salt Creek, and levels close to depletion existed at both stations on the East DuPage. Levels of turbidity were also high, particularly in the East DuPage.

It is interesting to compare the results for ortho- plus MIC P_2O_5 and apparent ABS with those in sewage treatment effluents (Table 5). Values of phosphate and apparent ABS at locations J and K are the same as those for sewage effluents, indicating almost no effective dilution by streamflow for the discharges from the many treatment plants tributary to the East DuPage River. Values of P_2O_5 and ABS at locations G, H, and L are less than those in sewage effluents, which indicates that greater dilution was available in these streams.

The high values of ortho- plus MIC P_2O_5 at location M on a creek tributary to the West DuPage River, are the result of the discharge of industrial waste from a plant which uses phosphate compounds in its operation. The high P_2O_5 levels at location L probably also result from this industrial-waste discharge. The extremely high values of hardness at M are also associated with the operations of the industrial plant. It should be noted that apparent-ABS levels in the tributary

creek are almost zero, confirming the absence of significant domestic waste, and in contrast with the levels found at the other sampling locations on the three streams.

Interpretation of Survey Results

The water quality data reported are representative of a wide cross section of Illinois surface waters. The results for the survey of lakes and reservoirs, sources generally free of significant domestic waste, showed ortho- plus MIC P_2O_5 levels of less than 0.1 ppm and apparent-ABS levels of less than 0.01 ppm, on the average (Table 1). As almost no synthetic detergents are expected to find their way to these sources, the phosphate found probably stemmed chiefly from land drainage, and the apparent ABS measured

TABLE 5
Mean P_2O_5 and ABS in Four Illinois Sewage Treatment Effluents

Plant Location	P ₂ O ₅		Apparent ABS
	Ortho + MIC	MIC	
	Mean Concentration — <i>ppm</i>		
Southwest Champaign	12.47	0.84	2.09
Arthur	16.89	2.12	3.11
Sullivan	26.31	2.14	2.83
Elmhurst	17.29	1.37	2.69

is probably the result of positive interferences.^{7, 8}

On the other hand, results of the general survey of major drainage basins indicated ortho- plus MIC P_2O_5 levels of less than 1.0 ppm P_2O_5 and apparent-ABS levels of less than 0.2 ppm, on the average. Condensed P_2O_5 (MIC) was approximately half of the ortho- plus MIC P_2O_5 . The highest levels of phosphate and apparent ABS were observed mostly in rivers such as the Mississippi and Illinois, which receive wastes from large upstream populations. Small streams, however, also yielded high levels of phosphate and apparent ABS whenever contributions of domestic wastes were significant in relation to dilution.

The Kaskaskia River survey provided considerable data on water quality in general, and indicated that the overall mean ortho- plus MIC P_2O_5 and ABS levels were 0.43 ppm and 0.08 ppm, respectively. At the New Athens sampling station, where the Kaskaskia drains an area of 5,220 sq mi with a population of about 100,000, the mean ortho- plus MIC P_2O_5 concentration was 0.43 ppm and the mean apparent ABS was 0.08 ppm (Fig. 7). Dissolved-oxygen data indi-

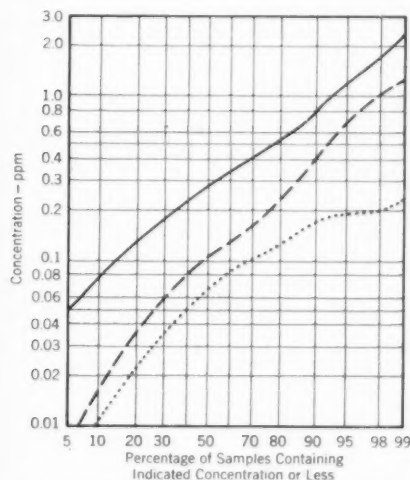


Fig. 6. Phosphate and ABS Concentrations in 125 Samples of Kaskaskia River Water, 1956

The solid, dashed, and dotted curves represent data for ortho- plus MIC P_2O_5 , MIC P_2O_5 , and apparent-ABS, respectively.

cate that the stream was not subject to severe pollution. The data on hardness and alkalinity show mean values

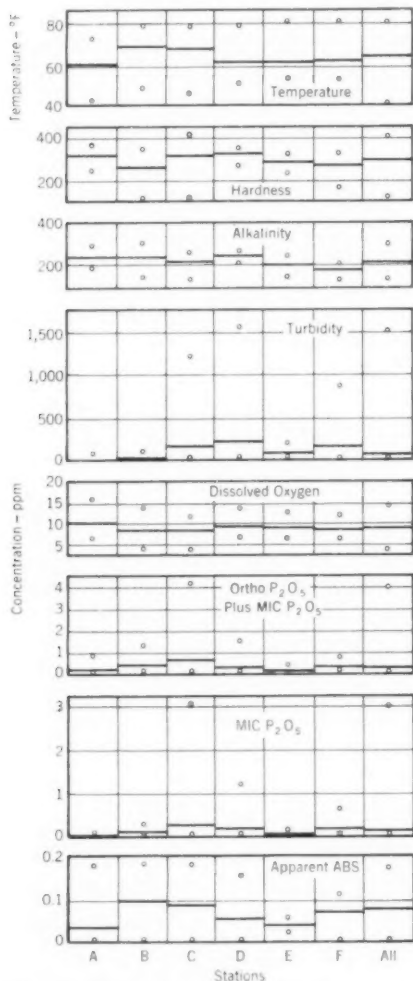


Fig. 7. Mean, Low, and High Values for Kaskaskia River Water Quality Data, 1956

Plotted points represent low and high values; horizontal lines are mean values. Sampling stations are identified by location in Table 3.

of about 300 ppm CaCO_3 and 225 ppm CaCO_3 , respectively. Similar data on mineral quality have been reported by Larson and Larson,¹⁰ who also reported turbidity ranging up to a 90 per cent value of 200 ppm for the upper Kaskaskia. Turbidity values for the upper Kaskaskia in the present

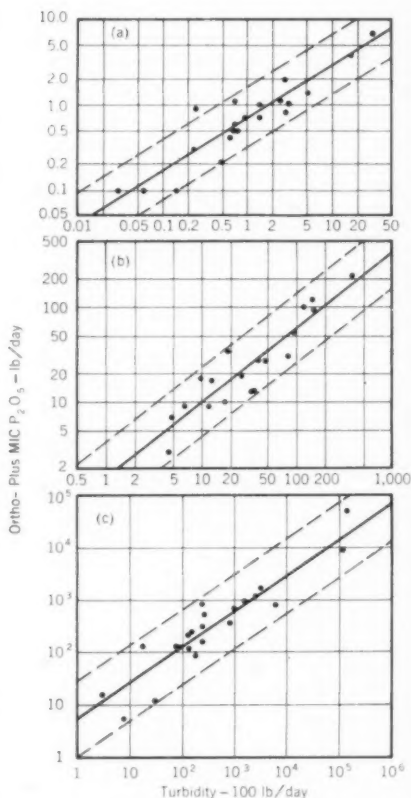


Fig. 8. Relationship Between Ortho-Plus MIC P_2O_5 and Turbidity at Three Locations on the Kaskaskia River, 1956

Parts a, b, and c give data for Bondville, Ficklin, and Shelbyville, respectively. The dashed lines represent the 95 per cent confidence limits.

survey were found to range up to a 90 per cent value of about 100 ppm, with a median of about 30 ppm.

The observed correlation between the quantities of turbidity and phosphate at the Kaskaskia sampling stations tends to show the significance of land drainage in relation to stream phosphates. Agricultural land drainage in the extensively cultivated Kaskaskia basin has been estimated to contribute approximately 45 per cent of stream phosphate, on the average.²

In considering the data on phosphates and ABS for the Kaskaskia River, it should be remembered that the daily discharge for the dates of sampling at Shelbyville was generally below the long-term average discharge of the period of record (Fig. 3)—that is, 1955 and 1956 were dry years. Therefore, because of limited dilution, the reported concentration of phosphates and ABS could be expected to be somewhat higher than in an average year.

In contrast to the water quality data for the Kaskaskia survey, results for the DuPage watershed area indicate rather severe pollution. The location on one of the streams of an industrial plant using phosphates and other chemicals in its operation complicates the interpretation of mineral data. Hardness results, with the exception of those for the West DuPage River, agree with those of Larson and Larson.¹⁰

The stream quality data obtained in the DuPage area are not from water supply sources; indeed, they are typical of highly polluted surface waters, resulting from low streamflow and the discharge of excessive quantities of untreated domestic waste. The concentrations of synthetic-detergent components (ABS and phosphate) were

similar to those found in sewage effluents.

Summary

The results of the various surveys of Illinois surface water indicated the following:

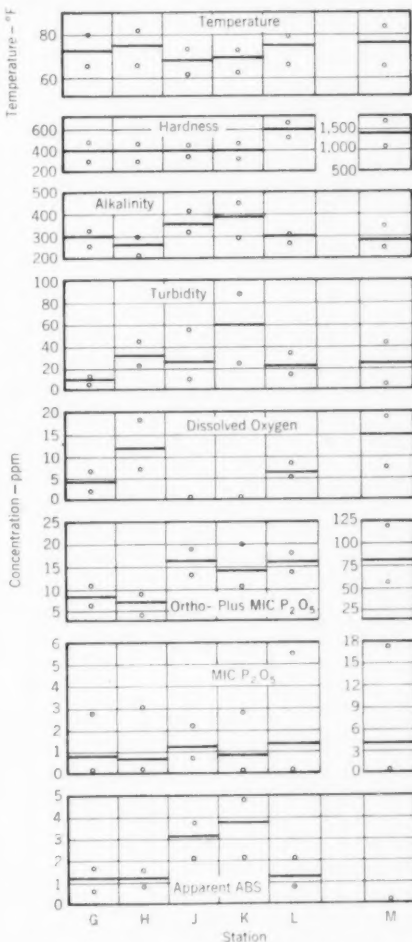


Fig. 9. Mean, Low, and High Values for DuPage Water Quality Data, 1956

Plotted data represent low and high values; horizontal lines are mean values.

1. The concentration of MIC P_2O_5 in unpolluted lakes and reservoirs in Illinois was generally lower than 0.1 ppm, and ortho- plus MIC P_2O_5 was generally lower than about 0.2 ppm.

2. Maximum inorganic condensed (MIC) P_2O_5 in Illinois streams used as water supply sources was usually less than 0.5 ppm, and ortho- plus MIC P_2O_5 was usually less than 1.0 ppm.

3. Apparent-ABS levels, as determined in the general survey of Illinois streams known to be receiving sewage effluents, were, with only three exceptions, less than 0.2 ppm and often less than 1.0 ppm. The apparent ABS levels in lakes and reservoirs were observed to about 0.01 ppm, on the average.

4. Levels of ortho- plus MIC P_2O_5 , MIC P_2O_5 , and ABS in highly polluted waters, which were not water supply sources, were approximately the same as those found in domestic sewage effluents—10–20 ppm, 1–2 ppm, and 2–5 ppm, respectively.

5. Computed quantities of ortho-plus MIC P_2O_5 in the Kaskaskia River showed correlation with computed quantities of turbidity, supporting the importance of land drainage in relation to stream phosphates.

6. As demonstrated by stream quality results in the DuPage area, high levels of phosphate in streams may come from industrial sources. It is thus important that mineral data be considered in relation to upstream sources and to stream use.

Acknowledgments

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Rapid Method for Estimation of Total Phosphate in Water

—Reed S. Robertson—

*A contribution to the Journal by Reed S. Robertson, Chem. Engr.,
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THE process of changing complex condensed phosphate to orthophosphate is known by various names, such as hydrolytic degradation or reversion. In the analysis of total phosphate in water by the molybdenum colorimetric methods, degradation must be complete or results will be low. Reported results have frequently been found to be low.

Need for Rapid Test

Degradation is usually achieved by prolonged boiling with acids. Experience has shown that the amount of boiling needed to obtain complete degradation varies from sample to sample, even when the condensed phosphate is freshly added to the water. The process may require 1–4 hr, as it does with some magnesium polyphosphate compounds. Thus, a rapid, reliable method for total phosphate is definitely needed, particularly in control laboratories and for field use.

Study of Degradation

Some of the factors controlling rates of degradation of condensed phosphates were investigated. The study was in no way intended to be a comprehensive examination of the complex reactions that take place during the process; it was made to determine what combination of conditions would best assure 100 per cent degradation in the shortest

possible time. This study led to the improved method described.

Total-Phosphate Method

The rapid method for determination of total phosphate is described below:

Apparatus

Almost any visual comparator, colorimeter, or spectrophotometer may be used with this method. The only other equipment needed are the proper test cells for the instrument used (able to withstand heating directly), three graduated pipettes, and a source of heat, such as an electric hot plate.

Reagents

Acid-molybdate reagent. Dissolve 9.15 g of reagent grade $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ in approximately 700 ml of distilled water and add 1.50 g of reagent grade $\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$ dissolved in 191 ml of cp concentrated nitric acid. Dilute to 1 liter with distilled water and mix thoroughly. This reagent is stable for at least 10 months. In direct contact with rubber, it may become slightly discolored, but apparently this does not affect the usefulness of the reagent. The reagent should be stored in glass, not polyethylene; otherwise only normal precautions are required in handling.

Acid reagent. Make in same manner as acid-molybdate reagent, but omit

the ammonium molybdate. For less precise work 6*N* HCl may be substituted for this reagent.

Reducing solution. Weigh out separately 0.75 g of 1-amino-2-naphthol-4-sulfonic acid (98+ per cent, Eastman Kodak No. 360), 41.92 g of reagent grade Na_2SO_3 , anhydrous powder, and 69.85 g of reagent grade $\text{Na}_2\text{S}_2\text{O}_5$, anhydrous powder. Grind the sulfonic acid together with a small portion of the $\text{Na}_2\text{S}_2\text{O}_5$ powder in a clean, dry mortar. Dissolve the remaining materials in approximately 950 ml of distilled water, add the finely ground sulfonic acid, mix thoroughly and dilute to 1 liter with distilled water. Store solution in a dark bottle at temperatures not exceeding 30°C. The solution may become slightly discolored with time, but, if properly stored and *not contaminated*, it will give satisfactory results for 4 months or more. Be sure the sulfonic acid used to make this reagent is not more than 4 months old or, at least, has no purple coloration. A slightly pink color is normal.

Distilled water. Although distilled water is recommended, almost any phosphate-free water should be satisfactory. See comments on interferences.

Procedure

Add 3.0 ml of sample to each of two clean, matched test cells (17–20 ml in capacity). Add 2 ml of the acid reagent to the first cell and 2 ml of acid-molybdate reagent to the second cell. Mix and heat cells rapidly until the maximum yellow color develops in second cell. This should require approximately 5 min if heating is rapid enough. The reaction is complete when the samples boil. It is advisable to agitate the test cells slightly while heating to prevent superheating and loss of sample.

Remove the samples from the heat source and slowly add 10.0 ml of distilled water to both. Cool the samples in cold water to 20°–35°C. Time is not critical at this point. Add 0.5 ml of the reducing solution to both samples, mix well, and allow to stand for 5 min.

Zero the instrument on the first test cell (the blank which contains no molybdate), and take a reading on the second test cell. It is permissible to omit the first cell or blank and read

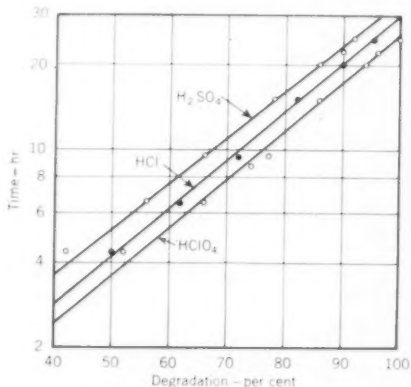


Fig. 1. Degradation Rates With Acids and a Glassy Sodium Polyphosphate (1.2 Na_2O :1 P_2O_5)

The phosphate content of all solutions was 50 mg/l as PO_4 ; initial pH 0.7; temperature 25°C.

against distilled water when the water sample tested is clear and colorless, or when less accuracy is required, or when the effect of the blank is already known and corrections have been made. Refer the reading to the calibration chart or curve for the particular instrument used. The instrument may be standardized by performing the test on a number of samples with known phosphate content. If a spectrophotometer is used, or other instrument with which

wavelength selection is possible, the wavelength setting should be 690 m μ .

Interference

Tannins and lignins, occurring naturally or added as treatment, do not interfere when corrections are made for the blank. The sample must contain less than 20,000 mg/l chloride (as NaCl). If the chloride content of the sample exceeds this amount and is known, a correction for the error should be possible. Normally, dilutions are required.

If a black or dark-brown color or a precipitate forms upon addition of the acid-molybdate reagent, sulfide is present and must be removed. This can be done by adding one drop of a 10 per cent potassium chromate solution to both cells before adding the acid reagents. Saturated bromine water may be used as an alternative reagent to remove the sulfide effect.

Ferrous iron gives a greenish hue to the color produced (this did not, however, change the reading obtained on a field instrument, where total absorption was measured). Arsenic and germanium must be absent, but at least 10 mg/l of vanadium, tungsten, antimony, or tin can be tolerated. Normal concentrations of other ions found in water samples are without effect. Silica does not interfere even at 100 mg/l SiO₂. The method is remarkably free from effects from even such diverse ions as chromate (500 mg/l), fluoride (400 mg/l), nitrite (100 mg/l), barium (600 mg/l as BaSO₄) and strontium (500 mg/l as SrSO₄). The figures given are the maximum amounts tested.

Glassware used in this test must be very clean and free of films. Cleaners containing phosphates should not be used; acid cleaning is best. If the test cells are emptied immediately after

reading and rinsed thoroughly with distilled water, they can be safely reused without further cleaning.

Variations in Test Conditions

The accuracy of this test is not affected by slight variations in the recommended concentrations or time periods. Readings taken before 5 min will give low results.

A pH of 0.7 or less must be maintained in the test solution before addition of the reducing solution to prevent interference from silica. There is enough acid added in the procedure to assure this pH even with waters having a total alkalinity of more than 1,000 mg/l (as CaCO₃).

An increase in the molybdate concentration in the acid-molybdate reagent, while other ingredients are maintained at recommended levels, increases the amount of color developed. The amount of color decreases with decreasing concentrations of molybdate. The use of twice the specified amount of acid-molybdate reagent, however, apparently has no effect. The final concentration of molybdate in the reagent was selected at a level at which silica is least likely to interfere.

At least 1.2 mg of bismuth nitrate is required for each test. The method provides 3 mg, which is enough for enhancement purposes in the presence of up to 20,000 mg/l chloride as NaCl. Additional bismuth is of little help when concentrations of chloride are higher.

The amount of reducing solution added may be varied from 0.2 to 0.8 ml without significantly affecting the results.

Temperatures below 20°C at the time of reduction give slightly low results, whereas temperatures above 35°C produce much darker colors and high results. As it is difficult to re-

produce exact temperatures in routine field tests, the use of a fixed temperature above 35°C was not considered a good means of obtaining increased sensitivity in the test.

Accuracy

The Beer-Lambert law is followed up to 20 mg/l phosphate as PO_4 . The reason it does not hold beyond this

able electric colorimeter mentioned above and would undoubtedly be much improved if a spectrophotometer were used. The accuracies obtained are considered more than adequate for general use, however.

Orthophosphate Method

If only the orthophosphate content is desired, it may be obtained by omit-

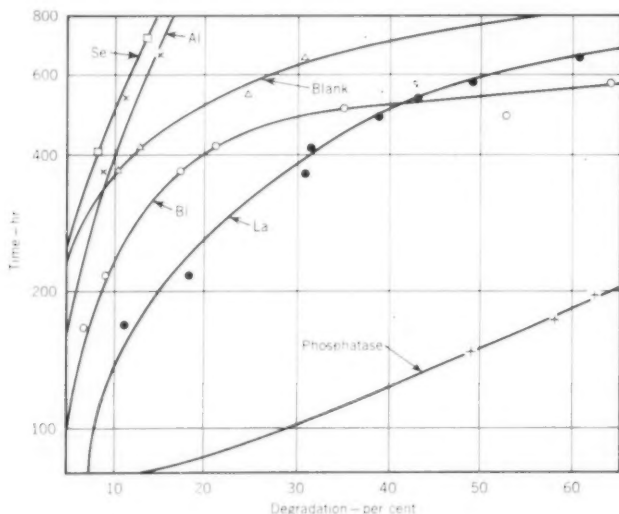


Fig. 2. Degradation Rates With Various Metal Ions and Phosphatase With a Glassy Sodium Polyphosphate ($1.2 \text{ Na}_2\text{O}:1 \text{ P}_2\text{O}_5$)

The phosphate content of all solutions was 50 mg/l as PO_4 ; initial pH 7.0; temperature 25°C; metal and phosphatase 10 mg/l.

point is not known, but the difficulty may be in the instruments used.

The standard deviation obtained for this test from 20 determinations was 0.08 mg/l PO_4 in the range of 0-5 mg/l and 0.24 mg/l in the range of 5-20 mg/l. The 95 per cent confidence limits for these ranges using the "T" method of Dean and Dixon² are 0.1 mg/l and 0.2 mg/l respectively. The measurements were made with a port-

ing the heating step. Be certain that the temperature of the sample is between 20°C and 35°C and that there is no long delay between additions of reagents.

Degradation Process

The degradation process has been studied by many others.^{3-5, 7, 9, 10} To the author's knowledge, however, none of them sought the objective stated

earlier. In the degradation studies, glassy sodium polyphosphates with molar ratios of 1.2 $\text{Na}_2\text{O}:1 \text{ P}_2\text{O}_5$ and 1.7 $\text{Na}_2\text{O}:1 \text{ P}_2\text{O}_5$, and glassy sodium magnesium polyphosphate with a molar ratio of 3.67 $\text{Na}_2\text{O}:1 \text{ MgO}:3.67 \text{ P}_2\text{O}_5$, were used because they were considered representative of the types of glassy condensed phosphates commonly encountered in practice. For the purpose of standardization and comparison, reagent grade disodium hydrogen phosphate was used.

Solutions of the various phosphates in covered tubes were submerged in a water bath at controlled temperatures of 25°C and 75°C under various condi-

standard colorimetric method.⁸ The progress of the hydrolytic degradation was traced by following the increase in orthophosphate content. The materials added are shown in Table 1.

All materials except the phosphatase, lecithin, and lignin were either cp or reagent grade chemicals. Cations were added as their nitrates, and anions were added as their sodium, potassium, or ammonium salts. Metals were added in powdered form.

Results With Acids

Sulfuric acid is frequently used to aid in the degradation process, yet it showed the poorest rate of all the acids

TABLE 1
Substances Tested In Degradation Process

Acids	Oxidizing Agents	Ions					Miscellaneous
HClO_4	NaBiO_3	Bi^{+++}	Ca^{++}	Ti^+	Fe^{++}		phosphatase
HNO_3	H_2O_2	La^{+++}	Ce^{++}	NO_3^-	Se^{++}		lecithin
Cl_3CCOOH	$\text{K}_2\text{S}_2\text{O}_8$	Sb^{+++}	Ce^{+++}	SO_4^{--}	Al^{+++}		lignin
HCl	KIO_4	Pb^{++}	Na^+	$(\text{C}_2\text{H}_2\text{O}_2)^-$	Sn^{++}		Mg°
H_2SO_4	KClO_3	Mg^{++}	K^+	F^-	Fe^{+++}		Zn°
	KMnO_4	Be^{++}	NH_4^+	Cl^-			Sn°
	$\text{NaBO}_2 \cdot 4\text{H}_2\text{O}$	Zn^{++}	Li^+				Fe°
	Na_2O_2	Hg^{++}					

tions of acidity and in the presence of a number of ions and substances (see Table 1) at concentrations of 1–10 mg/l. The pH of the initial mixture was adjusted at the start of each run to 7.0 or 0.7 by the addition of either nitric acid or ammonium hydroxide as needed, except in the studies of different acids, when other acids were substituted for the nitric acid. A glass electrode pH meter, which had been standardized against a pH 6.86 (25°C) Bureau of Standards buffer, was used for this purpose.

Periodically, portions of the solutions were withdrawn and the orthophosphate content determined by a

tested. Figure 1 gives typical results for the acids tested. Nitric and trichloroacetic acids have been omitted from the figure for clarity; they had rates very close to that of perchloric acid. The differences shown were even more evident at high temperatures, and the rates were much higher and the plots were curved, showing a tendency for the rates to slow down as degradation neared completion. Table 1 lists the acids in order of effectiveness.

Results With Oxidizing Agents

Because there seemed to be some correlation between the oxidation potential of the acids and their ability to

bring about degradation rapidly, a number of oxidizing agents was tested. Sodium bismuthate was the only substance in this group that showed a promising rate. Part of the apparent high rates obtained with bismuthate were later shown to be the result of an enhancement effect in the phosphate test.

Effects of Other Ions

The discovery of the bismuth effect led to the investigation and testing of

substances in the degradation process than on others.

The order of listing of ions in Table 1 has significance only for the first two and last five. The first two (Bi^{+++} and La^{+++}) speed up degradation, whereas the last five (Fe^{++} , Se^{++++} , Al^{+++} , Sn^{++} , and Fe^{+++}) retard it. Of the other ions and miscellaneous materials listed in Table 1, only phosphatase could be said to have a significant effect.

No attempt was made to control pH after the initial adjustment. A slight drop usually occurred as degradation

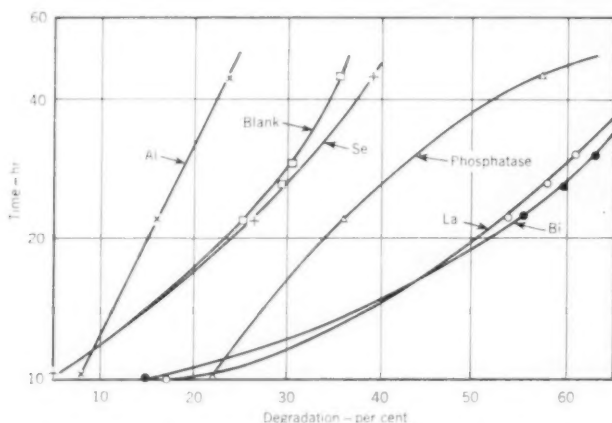


Fig. 3. Degradation Rates With Various Metal Ions and Phosphatase With a Glassy Sodium Polyphosphate ($1.2 \text{ Na}_2\text{O}:1 \text{ P}_2\text{O}_5$)

The phosphate content was 50 mg/l as PO_4 ; initial pH, 7.5; temperature 75° ; metal and phosphatase 10 mg/l.

the ions listed in Table 1. Figure 2 shows the results obtained with those ions and the enzyme, phosphatase, which were significantly different from the blank.

Figure 3 shows the same group under the same conditions but at a higher temperature. This test shows the important part temperature plays in these reactions and the fact that it has more effect on the activity of some

proceeded. It did not follow, however, that the tests showing the lowest pH's showed the greatest degradation.

It was certain that some substances seemed to activate the degradation process and that others deactivated it. The metal type activators seem to work by forming salts or complexes with the condensed phosphates, which are apparently less stable than the condensed phosphate alone, particularly when

heated.⁸ Frequently these products were insoluble, but they redissolved easily with the acid reagent on heating. Deactivators may act in a similar manner, but they form products which are more stable.

The relative effectiveness of various conditions, or combinations of conditions, in reaching total degradation in the shortest possible time is given below:

1. Acid and heat and metal activator
2. Acid and heat
3. Acid alone
4. Heat and metal activator
5. Heat and enzyme
6. Heat alone
7. Enzyme alone
8. Metal activator alone
9. Condensed-phosphate blank
10. Metal deactivator alone

The order of effectiveness applies to the condensed phosphates used in this study; it may be desirable to extend such studies to other phosphates.

Enhancement Effects

It was found that, if bismuth was present during the reduction of the heteropoly acid, the molybdenum blue color produced was greatly enhanced. The degree of enhancement was a function of the concentration of bismuth ion up to a critical concentration. This can be seen in Fig. 4. It is possible that this effect could even be used in a method for determination of bismuth within certain limits.

If a small amount of the disodium salt of EDTA is added prior to the reduction step, no enhancement takes place and the normal color develops. If the EDTA is added after reduction, the color, which is about three times the normal intensity, is gradually returned to the normal level. Without

EDTA, the enhanced color is stable for many hours. Because of these phenomena and because the enhanced color is still proportional to the phosphate content, it seems likely that bismuth actually becomes a part of the complex formed. Interestingly enough, the presence of bismuth did not increase the yellow color produced in the formation of molybdophosphoric acid.

Chloride contents of more than 20,000 mg/l NaCl also reduce enhancement. This is assumed to be due to the formation of the bismuth chloride complex ion. If the chloride content

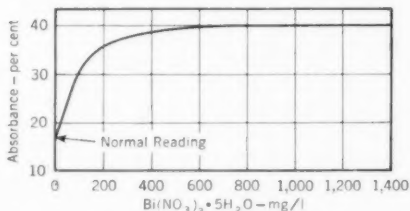


Fig. 4. Effect of Variations in Bismuth Content of Reagent

Ortho PO₄ was tested (at a concentration of 10 mg/l) with various amounts of $\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$ added in preparation of molybdate reagent. Readings were taken on a field type colorimeter.

is high enough the color is reduced to normal intensities.

Antimony produces similar enhancement effects. Though its effect is less, it is equally susceptible to removal by EDTA and more susceptible to removal with chloride.

Adding EDTA before or after reduction with stannous chloride in a standard method⁸ brought about considerable drops in color intensities, but the color could not be lowered to the level obtained normally with the sulfonic acid type (no bismuth present) of reducing agent. One explanation

for this may be that EDTA does not complex tin as completely as bismuth or antimony at pH's as low as 0.7. Perhaps, the greater speed with which the stannous chloride accomplishes its reduction may be partly responsible for the darker color it normally produces.

Bismuth had no apparent effect where hydrazine or stannous chloride was used as the reducing agent.

Comparison of Reducing Agents

Figure 5 permits comparisons of the calibration curves obtained using three reducing agents, 1-amino-2-naphthol-4-sulfonic acid, hydrazine, and stannous chloride. The method given by Boltz and Mellon¹ was used for the hydrazine curve. The methods given in the tenth edition of *Standard Methods*⁸ were used with the other two agents. Figure 5 also shows the curve obtained with the method reported in this paper with bismuth present. In all cases the Beer-Lambert law is followed for the range shown.

The changes caused by the three reducing agents were quite different. Of the three, hydrazine acted most rapidly. Molybdenum blue (maximum absorption at 690 $m\mu$) formed first, being rapidly replaced by the so-called heteropoly blue (maximum absorption at 835 $m\mu$).¹ This color appears less intense and has a greener hue compared to molybdenum blue. In time this greenish-blue color gave way to a yellow color which no longer showed a maximum at 835 $m\mu$.

Hydrazine required a higher pH than the other reducing agents in order to stabilize the color it produced. Soluble silica, however, became a serious source of error at pH's above 0.7, giving high results. Because of the silica problem, the lower color apparent to the eye, and the fact that few

field type colorimeters are equipped to utilize the added sensitivity this reagent provides at a wavelength of 835 $m\mu$, hydrazine was considered a poor choice for a reducing agent for a field-type phosphate method.

Stannous chloride acted almost as rapidly as hydrazine. The first color produced, again, was molybdenum blue; however, it was much more slowly replaced by the heteropoly blue. It was difficult to follow the changes that took place because of the gradual appearance of turbidity. The use of

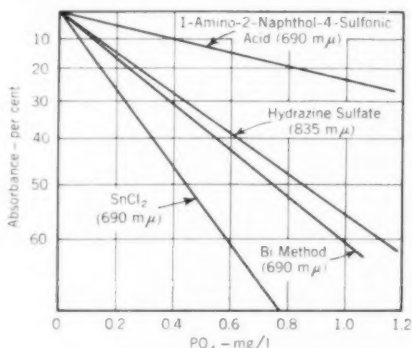


Fig. 5. Comparison of Phosphate Determination Methods

Readings were made in 1-in. cells using a distilled-water blank and a laboratory type colorimeter with a refraction grating for obtaining given wavelengths.

stannous chloride did not cause a silica problem, but would possibly give difficulties, particularly at low concentrations of phosphate, because of this agent's tendency to produce high blanks, its greater susceptibility to interferences, and its instability in solution.

The 1-amino-2-naphthol-4-sulfonic acid was much slower than the other two reducing agents, but the molybdenum blue formed was far more stable. The reagent, itself, is fairly

stable when properly prepared and kept free from contamination. For these reasons, as well as because of its lower susceptibility to interferences, it was felt to be the best choice for a rapid field test.

Conclusion

The test described makes possible the determination of total phosphate in the field in less than 15 min. The test may also be used with increased accuracy and sensitivity by measuring transmission at 690 m μ with a spectrophotometer. The method has been extensively tested in both field and laboratory with excellent results. Degradation is complete in 5 min heating time, even in work with magnesium polyphosphate in the presence of deactivating ions.

The normality of the acid-molybdate reagent is only approximately 3N compared to the 6-10N recommended in other methods. The lower normality makes the reagent much safer for field use.

This method was intended for use in determination of all soluble inorganic phosphates and phosphate complexes in water. It has been shown to work equally well for insoluble phosphates at reasonable concentrations of suspended matter. Although it was never intended for organically combined phosphate, a number of tests with adenosine triphosphate in water showed that the test measured all of the phosphate, whereas normal methods were unable to do this without first destroying, at least partially, the organic part of the molecule. In spite of this success, the test is not generally recommended for organic phosphates.

Acknowledgments

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Basic Mechanisms of Coagulation

A. P. Black

A paper presented on Jul. 13, 1959, at the Annual Conference, San Francisco, Calif., by A. P. Black, Research Prof. of Chemistry, Univ. of Florida, Gainesville, Fla. The investigation was supported by Research Grant RG-4516 from the National Institutes of Health, USPHS.

OF obvious importance to a discussion of coagulation for the removal from water of turbidity—which may be either organic or inorganic, organic color, or the sludges resulting from lime or lime-soda softening—are the basic mechanisms involved. Because the substances that cause turbidity in water are, for the most part, colloidal, it is necessary that the water chemist familiarize himself with the properties and behavior of colloids.

Properties of Colloids

Colloid chemistry was originally defined as the physical-chemical phenomena of particles within a certain size range, about 5–200 $m\mu$. This definition, however, was soon found to be too confining, for the most important properties of colloids are surface effects at interfaces, and the surface areas involved are extremely great. If a 1-cm cube of pure gold is placed into a 1-liter beaker filled with distilled water, the surface area of the gold is 6 sq cm. The brightly polished gold surface reflects practically all the incident light, and the properties of the water and of the gold are affected to only a minute degree by virtue of their physical contact. If the gold cube is dissolved in

aqua regia and reduced under proper conditions with tannic acid or sodium formate, the result is dramatically different—a purple sol, long known as the “purple of Cassius.” It may be filtered unchanged through analytical-grade filter paper. It may be kept, under proper conditions, for years without settling. Much of the light entering the sol is scattered. The colligative properties of the system, its boiling point, freezing point, osmotic pressure, and vapor pressure have all been slightly but measurably changed. Perhaps most important of all, when the sol is placed in an electrical field between charged poles, the particles migrate to the anode, indicating that they possess a negative charge. The size of particles in the sol is within the limits stated before, and the surface area of the 10- $m\mu$ particles made from the 1-cm gold cube has now increased to 6,000,000 sq cm, more than twice the area of a tennis court! The properties of the turbidity, organic color, and softening sludges, which are to be removed by coagulation in water treatment, are, in general, the properties of this sol. It is important, therefore, to understand the forces that surround the particles of such sols and give the particles their remarkable properties.

Instability and Stability Factors

The two most important instability factors are the Brownian movement and the Van der Waals forces of attraction. The Brownian movement is the movement imparted to the sus-

particle. Although the nature of the Van der Waals forces is not well understood, they may be described as molecular cohesive forces that increase in intensity as the particles approach each other. They become more effective with decreasing particle size.

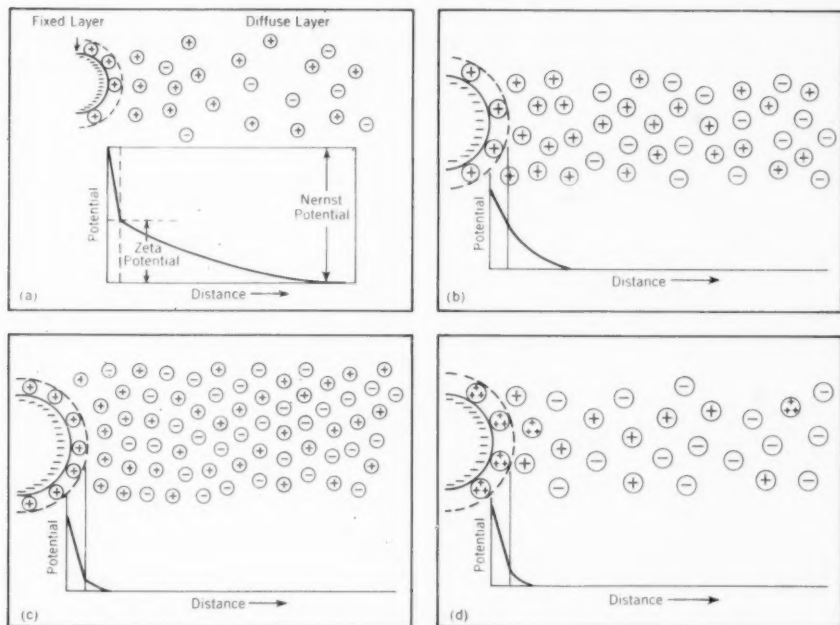


Fig. 1. Source of Zeta Potential and Effect of Ions of Opposite Charge

Fig. 1a represents a negative colloidal particle in a low concentration of monovalent ions. As the ion concentration increases from that in 2b to that in 2c, more positive ions enter the fixed double layer, and the zeta potential is reduced. In 2d, a trivalent positive ion has entered the fixed double layer and so reduced the zeta potential that coagulation would probably result.

pended sol particles because of their impact with invisible, rapidly moving particles of the medium. It is, therefore, essentially a thermal effect that tends to drive particles closer to each other and even causes them to penetrate the force fields surrounding each

The most important stabilizing factors are hydration and the zeta potential. Hydration is the property possessed by some particles to attract relatively large numbers of solvent molecules to their surface. When the solvent is water, such particles are

called hydrophilic, and, as has been said, contact between particles is hindered by the solvent "sandwich."

Nature of Zeta Potential

Zeta potential refers to a surface charge of colloidal particles which causes the particles to migrate in an electrical field to the pole of opposite charge. Zeta potential may be the result of selective adsorption of ions

pictures a stationary layer of ions on the surface of the particle surrounded by a movable diffuse layer extending out into the solution. A rapid drop in potential occurs between the particle and the stationary layer, and a much more gradual potential drop occurs between the stationary layer and a point in the solution at which electroneutrality exists. The overall potential is called the chemical or Nernst potential,

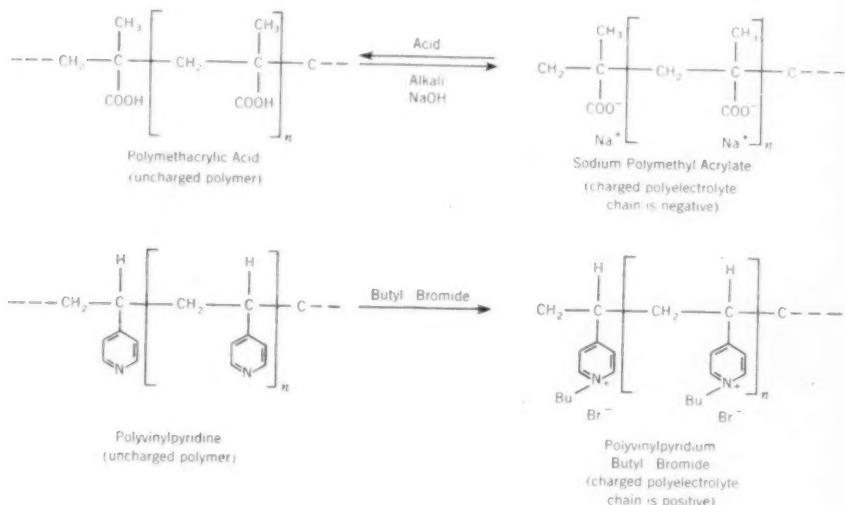


Fig. 2. Anionic and Cationic Polyelectrolytes

Each dissociating sodium ion leaves a negative charge site along the chain of sodium polymethyl acrylate. Each dissociating bromide ion leaves a positive charge site along the chain of polyvinylpyridinium butyl bromide.

from the solution or of residual valence forces, or both. The original Helmholtz picture of a charged colloidal particle showed a closely held double layer of charges of opposite sign. Electrophoresis—the movement of charged particles in an electrical field—could not, however, be explained by such a picture. Gouy¹ and Stern² proposed the diffuse-double-layer theory, which

whereas the lesser potential between the stationary layer and the solution is called the zeta potential. The latter makes it possible for the particle to move within a charged electrical field (Fig. 1a). Because the motion of charged particles in an electrical field is independent of their size or shape and dependent mainly on the zeta potential, the measurement of particle mo-

bilities affords a rapid and accurate method of determining the magnitude of zeta potentials. Because all the particles of a given sol possess the same zeta potential, it acts as a repulsive force preventing the individual particles from approaching each other.

Coagulation of Colloids

With the foregoing explanation of colloidal systems as a basis for discus-

decreased and increased. As the concentration of the added ion is increased, the diffuse layer is contracted until a point is reached when the Van der Waals attractive forces are stronger than the repulsive forces of the zeta potential, and coagulation results (Fig. 1, b and c). The valence of the ion of opposite charge is all-important, and the observed effects, in general, follow the Schulze-Hardy rule, which states

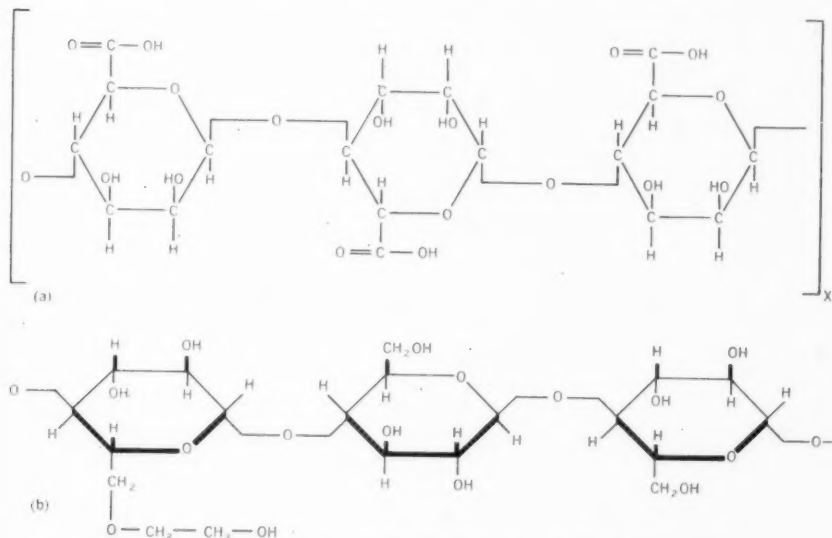


Fig. 3. Recurring Molecular Units of Natural and Synthetic Polymers

Fig. 3a shows the structural formula of alginic acid, derived from kelp; 3b shows hydroxyethylcellulose, a substituted natural polymer. See Fig. 4 for other molecular units.

sion, the next step is to understand the mechanism of coagulation of sol particles. Colloid chemists long ago showed that coagulation results when ions with a charge opposite to the charge of the colloidal sol are added to the colloidal solution. The ionic atmosphere of the diffuse layer surrounding each particle expands and contracts as the salt content of the solution is

that a bivalent ion is 50–60 times more effective than a monovalent ion, and a trivalent ion 700–1,000 times more effective than a monovalent ion (Fig. 1d). A colloid may also be precipitated by the addition of a colloid of opposite sign. This is called mutual coagulation.

The observed facts of water coagulation can be interpreted in terms of these

colloidal phenomena. The two coagulants most widely used in water treatment are aluminum and ferric sulfate. Both supply trivalent cations. Inas-

much as it has been shown that, in general, both turbidity and organic color in water are present as negative colloids, the significance and importance

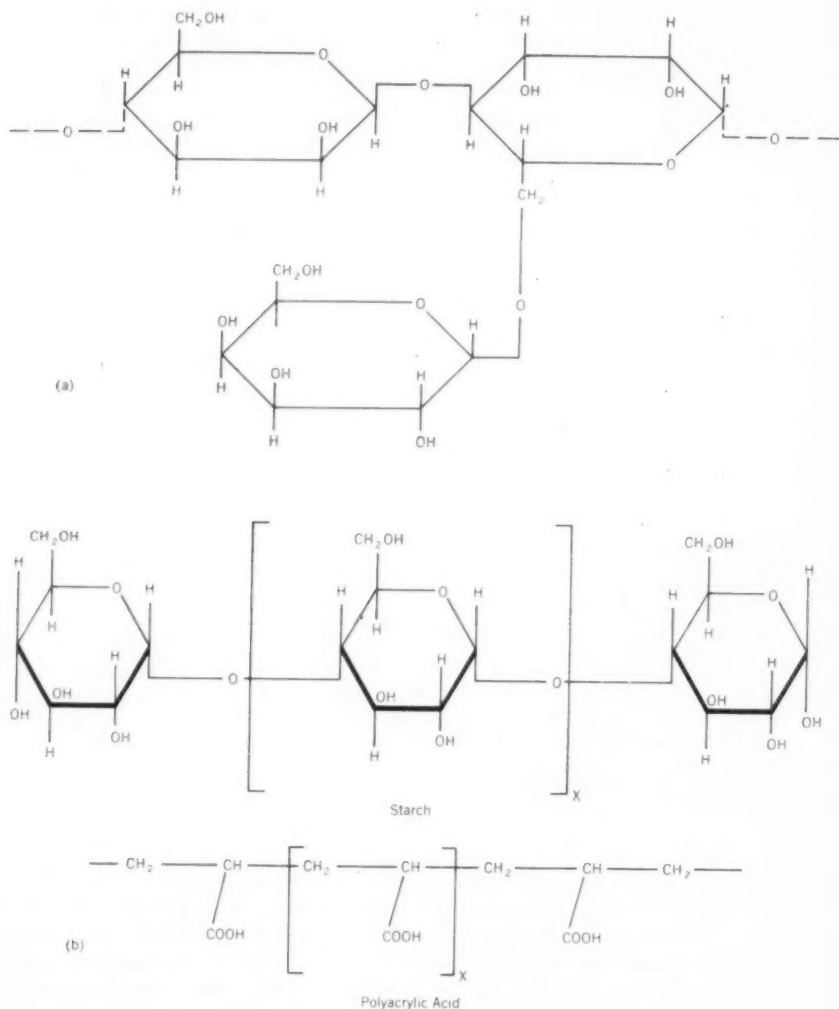


Fig. 4. Recurring Molecular Units of Natural and Synthetic Polymers

Fig. 4a shows the structural formula of a galacto-mannan, derived from guar gum. In 4b, a natural polymer, starch, is compared with a synthetic polymer; polyacrylic acid.

of the trivalent positive charge becomes immediately apparent. Secondly, when either aluminum or ferric sulfate is added to a water in the pH range of optimum coagulation, hydrolysis takes place. The formation of insoluble colloidal basic salts³ probably precedes the formation of colloidal aluminum oxide sols. Both possess positive zeta potentials and have the ability to precipitate negatively charged color or turbidity by mutual coagulation.

Colloid chemists have long recognized that rapid coagulation of a colloid sol usually takes place shortly before the zeta potential has been completely neutralized. Electrophoretic studies show that this is generally true where either alum or ferric sulfate is being used for the coagulation of either organic color or turbidity. When turbidity is present as clay, a further factor must be considered. It has been shown that the metallic ions in the diffuse double layer surrounding a clay particle constitute an ion-exchange system and that an equilibrium exists between them and other ions in solution. This property of ion exchange facilitates the substitution of the positively charged aluminum or ferric ions in the diffuse double layer surrounding the clay particle and, together with the number and size of the particles involved, governs the coagulant dosage.

Polyelectrolytes

The ability of such natural substances as starch, gelatin, and vegetable gums to act as coagulant aids has long been known. Recent years have witnessed the introduction of synthetic polyelectrolyte coagulant aids. Their use has stimulated an increased interest in the older natural products. Some of these materials have been found to be effective in extremely low concen-

trations and to produce spectacular results in many situations involving coagulation.^{4,5} It is necessary, therefore, to examine the nature and properties of these materials in order to learn about their mode of action.

The term "polyelectrolyte" was introduced by Fuoss⁶ to include those polymers which, by some ion-producing mechanism, can become converted to a polymer molecule having electrical

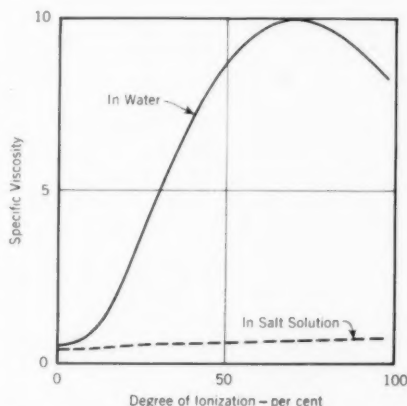


Fig. 5. Effect of Degree of Ionization of a Polyelectrolyte on the Viscosity of Its Solutions

The solid curve shows the rapid increase of viscosity of polymethylacrylic acid as it is neutralized by alkali. The dashed curve shows that there is almost no increase in viscosity in salt solution.

charges (ionized sites) along its length (Fig. 2). If the chain is formed by linking molecules of one molecular species, the compound is called a polymer. If the chain is formed by linking two or more different molecules, it is called a copolymer. Starch is an example of a natural polymer involving the linkage of a single molecular unit (Fig. 3 and 4). Proteins are polyampholytes involving the linkage of several amino

acids. Proteins may also have both positively and negatively charged sites. The behavior of sols of polymethylacrylic acid provides information on the possible mode of action of polyelectrolytes as coagulant aids. When so-

The viscosity is found to increase with the square of the molecular weight, so that polymers of high molecular weight provide sols of much greater viscosity than do polymers of low molecular weight (Fig. 6).

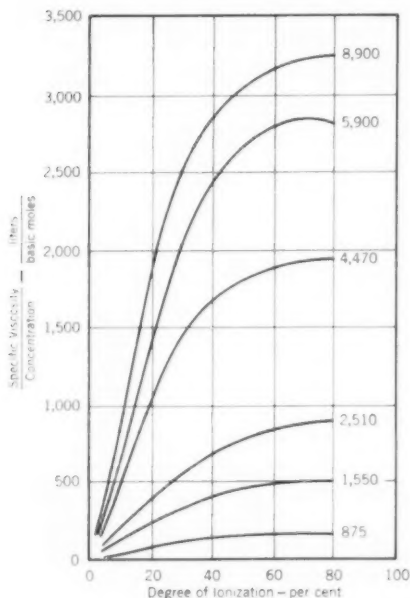


Fig. 6. Effect of Molecular Weight and Degree of Ionization on Viscosity

The relationship of specific viscosity to concentration is plotted against degree of ionization for six polymethylacrylic acids. The number near each curve indicates the number of simple molecules per macromolecule. The respective molecular weights would, therefore, be those numbers multiplied by 86, the molecular weight of the monomer.

dium hydroxide is gradually added to a water suspension of this acid, the specific viscosity is found to increase rapidly as the acid is neutralized,⁷ a maximum being reached at approximately 50-60 per cent neutralization (Fig. 5).

Mechanism of Polyelectrolyte Action

The uncharged polyelectrolyte may be compared to a coiled spring. This shape is the result of the random forces surrounding the polyelectrolyte. As a basic polymer is neutralized with acid or an acid polymer neutralized with base, the ions of the neutralizing acid or base dissociate from the chain, leaving charges at the points of dissociation. For example, if polymethylacrylic acid is 10 per cent neutralized with base, each tenth molecule in the long chain will have a negative charge. These charges will repel each other; the polymer chain will begin to uncoil and the molecule to stretch with consequent increase in viscosity (Fig. 7). As neutralization proceeds and more and more charge sites are placed on the molecule, it uncoils more and more and finally straightens out, reaching maximum viscosity. The charged sites on the polymer chain can attract ions or colloids of opposite charge or can cross-link with other polymers of opposite charge (Fig. 8).

Mechano-Chemical Effect

The behavior of polymer molecules provides a possible means of converting chemical energy directly into mechanical energy.⁸ This may be demonstrated in the laboratory (Fig. 9). Fibers of a polyacid soil-conditioning agent* are drawn from a concentrated solution and heat treated so that they become

* Krillium, a product of Monsanto Chemical Co., St. Louis, Mo.

insoluble in water. One end of a bundle of these fibers is attached to the inside bottom of a glass cylinder that can be filled with acid or alkali as desired. The other end of the fiber bundle is attached to one beam of a chemical balance, and a balancing weight is added to the opposite pan. The balance pointer indicates any physical change taking place in the system. If the cylinder is then filled alternately with 5 per cent hydrochloric

constituent of muscle fiber, is a very long protein molecule possessing ionized or ionizable sites. If, by enzyme action, the electrostatic energy of these molecules is suddenly diminished, the result might be a muscle twitch more rapid than, but similar in nature to, the change that has just been described. One may imagine the long chains of natural or synthetic polyelectrolyte coagulant aids as tiny muscles suspended in water which actually attract and draw together, by muscle action, tiny colloidal particles and agglomerate them into the visible flocs that can be removed by settling. If this is the true explanation of their action, then the name "polyelectrolyte coagulant aids" is consistent with their behavior. Also one would expect that their maximum activity would be exerted right after the preliminary phase of coagulation. In actual practice, it has been found that the aid being used should, in most instances, be added after and not before the coagulant. The number of these "little muscles" available for floc building, even at the minute dosages at which some of these aids are effective, is very large. For example, a dosage of only 0.2 ppm of a polyelectrolyte having a molecular weight of 100,000 would provide 120 trillion active chains per liter of water treated.

Although the above mechanism may possibly explain the action of some of the natural polyelectrolytes as coagulant aids, it fails to explain the action of others. The high viscosity of aqueous sols of the nonionic natural materials, such as starch and guar gum, is probably the result of the ready hydration of the highly hydrophylic molecules. Cationic starch, however, has recently been produced and is now commercially available. LaMer,⁹ in his study of the flocculation of phosphate

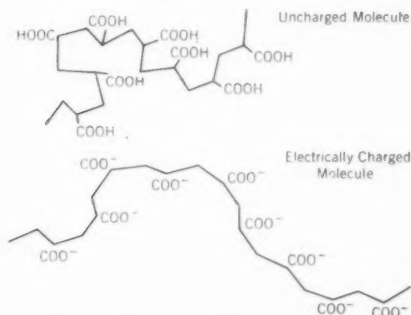


Fig. 7. Effect of Electric Charge on the Shape of a Molecule in Solution

The uncharged molecule is like a contracted chain, which might even be coiled or looped. The electrically charged chain has expanded and lengthened owing to mutual repulsion of charged sites along the chain.

acid and 5 per cent sodium hydroxide, the fibers will expand in the alkali, owing to the mutual repulsion of charged sites, and contract in the acid. With fibers about a foot in length and a counterpoise weight of 10 g, the movement of the pointer may be as much as 2-3 in. This so-called "mechano-chemical" effect is remarkably similar to that involved in the contraction of muscle fibers in the human body. The protein myosin, a main

slimes, found potato starches to be much more effective than those derived from corn or other sources. He attributes their effectiveness to their phosphate content, and suggests that specific cross-linking between the phosphate radicals—which normally occur in potato starch molecules, with calcium or other cations forming insoluble phosphates—is responsible for the specific flocculating power of potato starch and its derivatives. He further found that whereas electrolytes will coagulate colloiddally dispersed matter, starch, in the absence of electrolytes, will prefer-

indicate that the first product of the interaction of the aluminum ion with hydroxyl is the formation of small granules of aluminum hydroxide. These granules then aggregate to form flexible chains that grow in length, developing lateral forces. If the forces are strongly developed, the fibers line up, forming a platelike crystal. If, on the other hand, the lateral forces are not strongly developed, the result is a gel with a structure similar to that of a pile of randomly oriented matchsticks. It is possible that these flexible chains may behave like polyelectrolyte

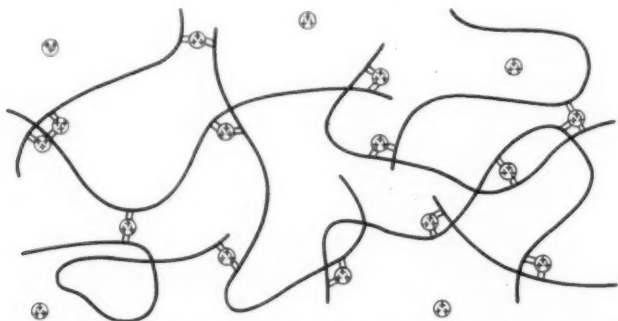


Fig. 8. Electrostatic Cross-Linking of Polymer Chains by Trivalent Ions

The diagram represents a gel of an acidic polyelectrolyte formed with polyvalent cations by electrostatic cross-linking.

entially coagulate the coarser particles. The metallic salts of alginic acid, derived from kelp, have been shown to have ion-exchange properties.¹⁰

Electron Microscope Studies

Studies of colloidal systems with the electron microscope, being conducted at the Frick Chemical Laboratory of Princeton University, may add to the information on the basic mechanisms of water coagulation.¹¹ The behavior of alum as a coagulant has been analyzed. With the aid of magnifications greater than 160,000 diameters, the studies

chains, in the same manner as described earlier.

Conclusion

By applying the techniques of the colloid chemist, the water chemist can greatly broaden his understanding of the series of changes that takes place when a coagulant, with or without a coagulant aid, is added to a water for the removal of color or turbidity. But there is still no logical explanation of the fact that certain polyelectrolytes may be quite effective in one situation and relatively ineffective in another.

The mode of action of some of the non-ionic natural materials is not clear. There are no fixed rules to guide the selection of a coagulant for use with a given water. The jar test is still the only aid. With the progress made in recent years, however, one may look forward, with some assurance, to the time when the selection of a coagulant or coagulant aid and the determination of its optimum dosage may be made with much more assurance than at present.

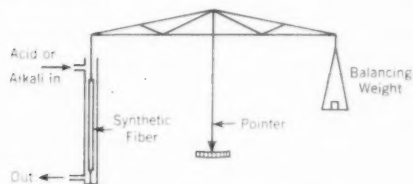


Fig. 9. Expansion and Contraction of Polyelectrolyte Fiber

The diagram shows the setup for a laboratory experiment demonstrating the direct conversion of chemical energy into mechanical energy. The fiber expands when alkali is added, causing the balancing weight to be lowered, and contracts when acid is added, causing the weight to be raised. The pointer indicates the direction and magnitude of the effect.

Acknowledgment

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Discussion

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The author deserves the thanks of the water supply industry for another contribution to his many excellent articles on coagulation and the zeta potential, a subject with so many facets that no brief discussion can do it justice. The overall investigations thus far made of coagulation and the zeta potential are only a beginning. On the other hand, the basic principles of stability and instability of colloids have been well developed by Verwey, Overbeek, and others, and all indications are that the practical aspects of this subject can be developed and adapted to the water supply field within a year or so. This will occur, however, only if water supply personnel have a genuine desire to improve the quality of treatment plant effluents, which, for any given plant, generally vary from excellent to poor, depending on the season of the year.

Zeta Potential Studies

The promise of the zeta potential for the control of coagulation is great. With the zeta potential, it is both possible and probable that a large, tough, highly absorbent and quick settling floc can be produced, not for only 6-9 months of the year but with complete uniformity all year round.

The principles of electrophoretic mobility, from which the zeta potential is computed, were first noted and partially developed about 156 years ago. This initial work apparently made little impression on scientists of the time, for the subject was not seriously studied again until Helmholtz conducted his

classic research in about 1877. Interest in the subjects must have waned again, only to reappear in the outstanding work of Smolukowski in 1906. Both Helmholtz and Smolukowski firmly established the basic principles of electrophoretic mobility and the zeta potential, which were further developed by Abramson in 1934. Recent studies of the zeta potential have been conducted by the Dutch, of whom the outstanding authorities are Verwey and Overbeek. Considerable work has been done by Kruyt, who did science a great service by collecting and editing the principal works of Verwey, Overbeek, and others working in the field of colloids and the zeta potential. The work of Stern should not be overlooked, as his initial concepts added to the understanding of the diffuse double layer and enabled more scientific rationalization of the condenser-like effect of electrons adsorbed at the surface of practically all particulate matter.

Unfortunately, none of these scientists ever considered water or water treatment in their basic concepts and research. It is a fact, however, that the greatest application of the zeta potential exists in the water supply field, for the volume of water coagulated daily in America probably exceeds the combined volume of industrial precipitates produced throughout the world in a year. This condition should make some impression on water utility chemists and engineers.

Electrophoresis

Whereas cell electrophoresis, as employed by Black, is used relatively little in America today, paper electrophoresis and electrophoretic separations are being utilized for extremely important

research. One of the foremost authorities on paper electrophoresis is Michael Lederer, head of research for the Institute of Radium in Paris. A few months of work by him on the nature of color in raw waters would probably provide more factual data than now exists. Interesting basic research is being conducted, with the aid of a grant, by Miland Bier and associates at the Institute of Applied Biology in New York City. Their present research includes the removal of practically the entire blood supply from test animals—ranging from mice to sheep—and after the blood is fractioned by electrophoretic methods, to divide it into a number of basic components, it is restored to the live test animal, without one of the blood components. Perhaps this basic application of electrophoretic methods to the problems associated with blood chemistry and biology may be an aid to understanding the causes of heart disease, blood clots, and hemophilia. Reasons may also be found to explain why certain people and races are relatively immune to certain diseases, whereas others are highly susceptible to them.

Treatment of Wastes

Electrophoresis and the zeta potential have considerable application in the treatment of wastes, both domestic and industrial. It is a fact that many of the end products of bacterial and microbial decompositions have a very low zeta potential. When activated sludges agglomerate well, and when trickling filter effluents clarify, the colloids have coagulated. This is a direct result of low zeta potential. McBain, in his classic work on colloids, considers that the great rivers of the world deposit sediments at the river mouths on dilution with sea water, owing to the

favorable zeta potentials occasioned by this dilution. He may have overlooked the fact that the end products of bacterial activity also cause low electrophoretic mobility, and that clarification can also be the result of sustained bacterial and microbial activity.

Coagulants and Coagulant Aids

Aluminum sulfate or the ferric salts alone have never been able to produce a completely satisfactory floc all year in any waters known to the writer. In the not too distant future, probably all scientifically operated water utilities will employ, in addition to a prime coagulant, one or two coagulant aids. During the winter months, the smaller quantities of silica in raw stream and reservoir waters are largely responsible for the very poor flocculation often noted. The present methods of silica activation permit its ready usage at all plants. There are many waters that do not require silica for a greater part of the year, but practically all water in climates characterized by winter freeze and high spring runoff do require silica during the winter and early spring months. The lack of silica is probably a result of reduced microbial metabolism in approximately the upper foot of the soil (hence, less carbon dioxide is generated for solution of silicate); freezing at the ground surface (which greatly reduces infiltration); and subsequent solution of alkaline earths and silicates.

Coagulation with alum alone often results in the formation of electronegative floc with an electrophoretic mobility in the range of about $1-3\mu/\text{sec}$ for a volt per centimeter. It is certainly possible to produce a satisfactory floc under such conditions, and, relatively, such floc may even be judged good or excellent. In the opin-

ion of the writer, however, this is simply an instance in which the London-Van der Waals forces of attraction, plus the multitudinous mechanical collisions occurring in the flocculation basins, are sufficient to overcome the forces of mutual repulsion, which are evidenced by a relatively high electrophoretic mobility and a relatively high zeta potential. For most streams and reservoir waters, if an appropriate surface-active agent is applied to change the electronegative floc to slightly electropositive floc, and if the electrophoretic mobility is reduced from a range of 1-3 to a range of 0-1, then improvement in floc formation is often astounding.

There are relatively few commercially available surface-active agents

that are now approved by USPHS for the treatment of water for domestic use. More than 2,000 of these agents, many of which may be applicable, are available in world markets. The USPHS can render a great service by cataloging, and approving or disapproving, the more promising ones. This involves an evaluation from many standpoints, including possible toxic effects and possible stimulation of algal and bacterial growths.

USPHS has demonstrated that toxic chemicals, such as sodium fluoride in proper dosages, can be safely employed by water utilities. It seems doubtful to the writer that many polyelectrolytes will be found to have a toxicity greater than that of sodium fluoride; a great number of polyelectrolytes will probably have relatively no toxicity at all.



Evaluating the Taste and Odor Control Problem

—John E. Kinney—

A contribution to the Journal by John E. Kinney, San. Eng. Consultant, Ann Arbor, Mich.

MUCH has been written on phenol as a contaminant of water supplies. Regulations limiting its concentration or even prohibiting its discharge into water have been adopted by regulatory agencies. Techniques developed to destroy phenols have been integrated with treatment plant operations. The cost of research work on phenol as a contaminant has been enormous, a cost that cannot be expected to be spent on every other contaminant. And yet, with all the research, the role of phenol is uncertain. There is a definite lack of agreement among the authorities on a limiting level for phenol. There is even a lack of agreement on what constitutes phenol and how to measure it. There is much criticism of adopted criteria, but few constructive suggestions on what the criteria should be.

Recent Surveys

Four years of surveys on the Mahoning and Beaver rivers and at the Beaver Falls water treatment plant in Pennsylvania have now provided adequate data for defining the significance of phenol in taste and odor control. These four years of research are a tribute to two states, a water treatment plant, and industries in the Youngstown, Ohio, area.

The work was started by Youngstown Sheet & Tube Co. because it was interested in knowing what hap-

pened to the phenol concentration as the flow of water moved downstream and crossed the Ohio-Pennsylvania state line. The company wanted to find out whether its closed system—in which phenol-bearing waste water is used to quench coke, with the heat destroying the phenol—was adequately removing phenol or whether supplemental treatment was needed. Ohio and Pennsylvania were also interested in the studies. The two rivers surveyed are water sources for two states with totally different approaches toward phenol treatment requirements. Both states were interested in obtaining data that would either substantiate their programs or provide the basis for changing them. The Beaver Falls treatment plant was vitally interested in improving the quality of its water supply. Bad-tasting water sometimes occurred despite treatment with chlorine, carbon, and chlorine dioxide.

The Youngstown Sheet & Tube Co. carried on the analytic work alone for nearly 2 years. Republic Steel Corp. joined to permit more intensive surveys and surveys over longer stretches of river. These joint surveys were intended to answer questions raised by the earlier studies. Additional help was provided by Sharon Steel Corp., Koppers Co., and Ohio Edison Co., in collecting water samples round the clock.

Beaver Falls Data

The first summary of data from the Beaver Falls treatment plant indicated the same inconsistencies that others had noted: (1) There was no correlation whatever between phenol concentration and odor problems. (2) Odor problems were only sporadic, never continuous, even though phenol was present nearly every day.

Over a period of 197 consecutive days, there were only 6 days during which phenol concentration was not measurable. Thus, there were 191 days of measurable phenol, but problems occurred on only 25 days. Difficulties occurred at times when the phenol concentration was only 2 ppb in the river water, and yet there was no problem at other times when the phenol concentration was more than 50 ppb. If 2 ppb of phenol causes odor problems, so should 50 ppb. If there were problems with 2 ppb but not with 50 ppb, then some other factor had to be involved.

A statistical evaluation of odor intensities in the river water offered a clue to the enigma. Occurrences of medicinal and chemical odors always coincided with high odor intensity. If the intensity was high, medicinal odor could be reported when the phenol concentration was low. But with low overall odor intensity, there was no problem, even when the higher concentrations of phenol were present.

For years, reports of laboratory tests have indicated that low phenol concentrations can be chlorinated to cause medicinal odors. The traditional approach to the problem of taste and odor in public water supplies has always started with this assumption. Thus, the logical procedure was to measure phenol concentrations when medicinal odor occurred to determine the concentration at which the difficulty started.

Because phenol could be measured, the cause of the difficulty was not questioned. And phenol measurements were made only when medicinal odor was detected.

But the Beaver Falls data upset this approach. The fact that measurable concentrations of phenol were detected almost every day, with difficulties occurring only on certain days—and usually when the phenol concentration was lowest—did not conform to the expected pattern.

Therefore, a different approach had to be considered, one that put emphasis not on the limits of phenol concentrations but on the protection of public water supplies from undesirable tastes and odor. With control of taste and odor as the objective, there were certain issues that needed exploration. The first of these was the role of phenol in contributing to taste and odor. An explanation was needed of the relationship between the laboratory test data, which showed a great odor potential from the chlorine-phenol reaction, and the plant operating data, which indicated a slight odor potential. The second issue was whether taste and odor could be treated as entities and controlled as such. If they could, such a control would be far simpler than an attempt to develop and administer separate controls over each contaminant or group of contaminants.

Role of Phenol

In the early 1920's, a report from USPHS noted that, when the chlorine dosage is properly adjusted, as little as 2 ppb of phenol can cause an objectionable taste in water. The importance of the need to adjust the chlorine dosage properly was not appreciated. Later published reports agreed that low concentrations of phenol were potent. But these studies, and even those

of recent years, employed a technique that was not completely representative of water plant conditions. It called for incremental chlorination of a concentration of phenol. The portion having maximum odor intensity was then diluted with odor-free water, and the number of dilutions necessary to remove the odor was determined. The original concentration of phenol divided by the number of dilutions so determined was considered to indicate the minimum concentration of phenol that would develop an odor on chlorination. If the original phenol concentration was 100 ppb (a concentration commonly used), and 50 dilutions were required to remove the odor from the portion of maximum intensity, it was concluded that 2 ppb of phenol, when chlorinated, would produce objectionable odors. Perhaps the conclusion was correct, but it assumed that reactions at any concentration of phenol are the same. In fact, however, chlorination of 2 ppb of phenol directly did not duplicate results. The lack of agreement was blamed on analytic errors at the low concentration.

These tests did not reflect what happens at a water treatment plant. A plant cannot maintain the control needed for such incremental chlorination. Yet it was argued that phenol had the potential to cause odor, and control measures were mandatory. The tests also failed to define the intensity of the odor of chlorophenol. There are tables of comparative concentrations of various substances that can be detected by smell, but there is always the question of the composition of the chlorophenols that might be present. If the phenol concentration in raw water is to be used as a control on water quality, there should be a gage of the significance of phenol in creating taste and odor problems.

Thus, part of the Beaver Falls study was designed to determine whether a relationship existed between phenol concentration in the raw water and (1) odor intensity in either raw or treated water, and (2) the maximum odor that could be developed with incremental chlorination.

Samples were collected on the Mahoning-Beaver rivers upstream from industrial sources, in the area of the industrial discharges, downstream from industrial and municipal discharges, at the water intake, and from the finished water at Beaver Falls. No relationship was found between phenol concentration and the maximum odor developed by incremental chlorination. A sample with 28 ppb of phenol developed five times the odor intensity that resulted from a sample with 135 ppb. But there was a relationship between chlorine demand and maximum odor. The greater the chlorine demand the stronger the odor intensity, indicating that intensity was more dependent on other organics than on phenol. It is possible that this relationship with chlorine demand may not be true for all waters, inasmuch as all odorous compounds do not have a high chlorine demand. But the relationship did hold true for all the sampling points in this survey.

These laboratory tests pointed up two areas of interest: incremental chlorination could develop medicinal odor and the intensity of odor depended on the other organics present. The Beaver Falls study was expanded to evaluate these factors.

Effect of Chlorination

Chlorophenols were formed on incremental chlorination in the laboratory but not on marginal chlorination at the water plant. The laboratory tests indicated that medicinal odor could be

developed in the laboratory under some circumstances, but although Beaver Falls employed marginal chlorination, there was no record that this created medicinal odor during water treatment at the plant. Furthermore, medicinal odor was reported in the finished water only when it had been reported in the raw water, and then only when the odor intensity of the raw water was high. And whenever medicinal odor was reported in the finished water, the odor was always less than that in the raw water. These reports suggested that other organics were involved.

The question of why the chlorine was not causing the formation of chlorophenols at the plant remained. The answer to this was supplied by T. J. Powers of Dow Chemical Co. Work by Powers has shown that a substitution reaction of chlorine with phenol, resulting in the formation of chlorophenols, effects a decrease in the measurable phenol. As the substitution continues to form higher concentrations of chlorophenols, there is a continuing decrease in measurable phenol concentration.

Against this background information, a check was made on phenol concentrations before and after chlorination at the plant and after each step of incremental chlorination of samples in the laboratory. The data showed no decrease in phenol concentration following chlorination in the plant. There was no formation of medicinal odor. At the higher dosages of chlorine used in the laboratory, however, there was a decrease in phenol concentration when the chlorophenol odor developed. This indicates that no medicinal odor developed at Beaver Falls because the chlorine dosage was not sufficient to start the reaction. Repeated surveys measured the phenol concentrations in

the raw water and in the finished water; no undesirable taste was detected.

This result also highlights the weakness in the argument that phenol concentrations should be limited because phenol has the potential to cause odor when chlorinated. Such an argument fails to take account of the conditions necessary to realize the potential. It does not face the reality that in marginal chlorination at many plants the chlorine dosage necessary to cause a reaction is not employed. Many plants do not have the capacity for this dosage; other plants do not use a high chlorine dosage during normal operations.

Two possibilities deserve attention in considering the lack of reaction of the chlorine with the phenol at the treatment plant:

1. The chlorine has a greater affinity for other organics than for phenols.
2. Work by Powers showed that when the phenol is present in concentrations of about 20 ppb, more than 200 times the stoichiometric requirements of chlorine are needed as a potential to cause the reaction between phenol and chlorine to go to complete oxidation.

Therefore, it seems possible that a potential of chlorine is needed to initiate a reaction between chlorine and phenol when phenol is present in such low concentrations. This would explain why laboratory workers fail to develop chlorophenols when very dilute phenol solutions are used unless the chlorine is added as a relatively concentrated solution. Such additions would provide a potential in part of the phenol solution.

Role of Organics

The role of organics other than phenols was demonstrated graphically,

though indirectly. Realization of their importance came about as a result of an entirely different line of inquiry, which went into whether phenols were accumulating in pools along the Mahoning River and being flushed out at times of river rise. The data on daily phenol concentrations at the Ohio-Pennsylvania state line, a point below the dams on the river, were plotted for a 6-month period. On the same graph, the occurrences of odor problems at Beaver Falls were noted. High concentrations of phenol (600 ppb) were not accompanied by difficulties, which did occur, however, when the phenol concentrations at the state line were lowest.

A hydrograph was superimposed on these data. A flush-out after a prolonged dry spell caused no odor problems. Yet sometimes there were problems when the flows were maximum—that is, when the high flows caused maximum dilution of the phenol.

The inquiry also pointed out that the odor problems were sporadic, without relation to flow or phenol. This suggested that someone was dumping material into the river, usually at times when the river was high. Presumably, dumping at these times was intended to provide maximum dilution; actually, it occurred when time of passage to the water plant was shortest, so that the slug reached the plant without benefit of die-away.

A search for the sources of cleanout was undertaken. This took time, but it had the cooperative support of some industrial plants that were sources of cleanout. All but one of the odor occurrences coincided with industrial-plant cleanouts or with the drawdown of the digester of a sewage treatment plant which went directly to the Mahoning River. The one exception was

traced to the drawdown of a reservoir on another tributary to the Beaver River.

The industrial cleanouts, though containing much organic matter, did not contain large quantities of phenol and therefore had been ignored. With the emphasis on phenol as the cause of taste and odor problems, attention has always been directed toward discharges that carried the phenol load.

From a scientific point of view, the traceback to slug discharges was not quite as complete as was desired. Actually, some occurrences of taste and odor problems lasted longer than could be attributed to the known cleanouts. This indicated that not all sources were yet known. But corrective measures were installed, at relatively minor costs, by those plants whose cleanouts had been proved troublesome. With the cessation of the cleanouts and drawdowns, there was a noticeable improvement in the Beaver Falls water.

Taste and Odor as Entities

Strenuous objections have been made to the suggestion that the control for water supplies should be an odor determination. The objections sound valid: odor is subjective; what smells sweet to one may smell sour to another; a smoker reacts differently to odors than does a nonsmoker; and panels are notorious for their range of reactions to odors. But if a supply is to be protected from taste and odor, there must be some means of identifying sources of difficulty. A query directed to the control agencies in New York, Pennsylvania, Ohio, Virginia, Indiana, and other states resulted in replies indicating that none of these states had a water supply with continuous taste and odor problems. In all cities, the problems were sporadic. In some,

the intervals between the difficulties were short but still sporadic.

Because taste and odor problems are not continuous, the odor determination method does not have to be precise. It makes little difference if there is a slight, or even a marked, variation between analysts. The procedure needed is one that detects the gross variation in quality—that is, a procedure that determines when there is a problem, so that the source can be located, rather than one that defines the problem precisely.

Once again Dow Chemical Co. has provided the guidance. Over the course of years, the company has learned the importance of controlling odors and locating the sources of highly intense odor. Company studies determined the required screening procedures for odor determinations that can be uniformly made by either the same operator or different operators. It was learned that odors could be fractionated and their sources defined. There could be no across-the-board description as presently found in analytic methods manuals, but in any situation a definition of sources of odor could be developed. All of this information was made readily available.

Using the Dow procedure, an odor survey was made of the Mahoning and Beaver rivers. The results were most interesting. Of nine observers, two could smell nothing. The determinations of the others on intensity varied only within one dilution. So close an agreement, however, was not shown on the descriptions of odor. The odor intensity data indicated a substantial natural die-away, but a slug cleanout was detected and traced downstream.

In an effort to provide an alternative to the description of odors by observers, tests were made on oxygen

demand, using both permanganate and chlorine. These tests offered confusing results when plotted for the full length of the river. There was an indication, however, that characteristics of individual discharges might be defined according to their oxygen demand. For instance, if the water plant received a slug of material with high odor intensity, knowledge of whether the slug caused an increase in chlorine demand could aid in determining the source of the slug. An intimate knowledge of sources of trouble and sources of wastes with definite odor characteristics could further aid in tracing a problem to its source.

Practical Applications

If the assumption were correct that high chlorine potentials are needed to start a reaction, and if the absence of other organic loads would insure a water supply with low chlorine demand, then even high phenol concentrations at the water intake should cause no trouble. But to determine whether chlorophenols are actually forming, tests of the finished water alone are not enough. It is still possible in a treatment plant using carbon and chlorine dioxide that chlorophenols might be formed by marginal chlorination, and yet the finished water could be acceptable because the carbon and chlorine dioxide had destroyed the chlorophenols. To determine whether the chlorine did, in fact, react with the phenol, and whether post-treatment removed chlorophenols, a special survey was conducted in 1957.

With the agreement of all parties concerned, the entire still waste from the Campbell coke plant of Youngstown Sheet & Tube Co. was discharged into the Mahoning River for 10 days. The discharge was well regulated; the

buildup was gradual. In case of trouble, the discharge would have been stopped immediately. To minimize the possibility of trouble, all potential sources of slug discharges were asked to cooperate.

The normal discharge of phenol at Campbell is 100 lb/day. This was increased to 3,600 lb/day. Samples were collected on a 15-min basis at the Beaver Falls plant, not only from the raw water but also after chlorination and after treatment with carbon and chlorine dioxide. The samples were analyzed for phenol and odor. If chlorine reacted with phenol, there would have been two indications: a decrease in phenol concentration, showing formation of chlorophenols, and the development of medicinal odor.

Chlorine-demand curves were determined. The plant operators carried on as though nothing unusual were occurring. Chemical dosages were not increased in anticipation of difficulties, none of which occurred. In fact, for a while the concentrations of phenol in the river at Beaver Falls were less than normal, despite the high phenol load discharged upstream. A check on phenol concentrations along the Mahoning River corroborated the fact that the rate of biologic oxidation of phenol increases with the concentration of phenol. With the temperature of the river between 70° and 80°F, the phenol was nearly gone before it reached the confluence with the Shenango River.

This test was conducted in February and March 1957. The discharge started on February 23. On February 27, there was a freezing rain. The ground was frozen and the runoff was rapid. River flow was four times greater than before. Temperature dropped to between 40° and 50°F. But even with the low temperature, there

was still marked die-away. And with the effect of dilution the concentration of phenol at Beaver Falls remained relatively low. When the flow diminished—the river temperature was still low—the concentration at Beaver Falls increased, and the effects of the treatment facilities on phenol were determined.

More evidence of the high rate of biologic destruction of phenol—even in cold water—when the initial concentration is high, is the fact that the highest phenol concentration measured at Beaver Falls at this time was 73 ppb. Concentrations of 100 ppb have been measured several times when the discharge was at the normal level of 100 lb/day.

The data indicated no reaction between phenol and chlorine at the dosages employed at the plant. The phenol passed through to the finished water without formation of chlorophenols. This agreed with the work at Dow Chemical Co. Laboratory checks with increased chlorine dosages showed, however, that when the dosage was properly adjusted, medicinal odors could be developed.

Carbon reduced phenol concentrations only when the phenol exceeded 18–19 ppb. But the carbon did not reduce phenol concentrations by any consistent amount or to any given level, nor did it at any time remove all phenol. When the phenol concentration was very low, there were indications of a bleedback of phenol from the carbon. Chlorine dioxide, in the dosages employed, had little or no effect on the phenol concentration, but it did reduce odor. Phenol concentrations in samples collected in the distribution system were the same as those in the water leaving the plant. No difficulties developed in the mains. Pre-

vious surveys have shown that concentrations of phenol in the finished water leaving the plant have been as large as 103 ppb without the occurrence of any difficulty.

Recommendations

These surveys have not only explored the theoretic reasons for taste and odor difficulties at treatment plants but have also provided proof that plants can have better water if taste and odor are considered as entities and controls are developed for them. To accomplish this, costly and time-consuming survey work may be required. Definitely required is the cooperation of all concerned in making a frank and honest appraisal of all sources of difficulty.

These studies do not show that Beaver Falls now has an excellent-tasting supply. The strong septic odor from sewage, measured at the same odor intensity during the steel strike in 1956 as when the mills are operating, still persists. But the periodic, strong chemical odors were traced to their sources, and relief from this trouble was provided.

Remarks have been made that the findings on the Mahoning-Beaver river system cannot be applied to other systems. It is true that the Mahoning is used by industry more than many other rivers. Also, the river sometimes has temperatures higher than 100°F in the winter. At times of high temperature, the biologic oxidation of organic matter, measured in terms of phenol and oxygen, is very great. But at other times, the temperature is almost freezing. And, as measured at the Beaver Falls intake, the phenol concentration at times exceeds that reported at many other plants.

But these characteristics do not limit the applicability of the data to this river

system or area. Other water plants have odor problems, and the problems are sporadic, even though the plants are located downstream from industrial areas. A check of water plants along the Ohio River provided information that phenol could be measured daily, but its presence did not usually result in difficulties. When odor problems did arise, they were sporadic and were evident in the raw water as well as in the finished water.

Efforts to obtain a better quality water in any area can be facilitated if certain facts and conditions are recognized. Until standard plant practices and techniques are able to insure that taste and odor are controlled in the finished water, there will be a continuing program of strict regulations on industrial discharges. Causes of taste and odor cannot be discerned by the average consumer. To argue that a taste was not caused by phenol, for instance, is academic to the consumer. All taste and odor in water are objectionable. There are, however, certain basic odor qualities peculiar to each supply that will not permit a prescribed limiting threshold intensity or characteristic pertinent to all supplies. The qualities peculiar to a supply are acceptable to its regular consumers, but variations of normal quality are not acceptable and should be controlled. Prime causes of great variation from the normal product include: cleanouts of equipment; breaks in storage or transmission facilities; periodic drawdown of equipment or storage facilities; drawdown of reservoirs, with release of water containing small quantities of oxygen and large quantities of organic matter; drawdown of sewage treatment plant digesters; and batch dumping of cleaning solutions or oils.

Slugs of material of high odor intensity cause trouble; so do materials

of high chemical demand. The latter require that increased chlorine dosages be added to water. Consequently, a sufficient chlorine potential might develop to cause the reaction of chlorine with organics, including phenols, that would not occur with a smaller chlorine dosage. If the chlorine dosage is sufficient to start the reaction but not sufficient to cause it to go to completion, objectionable end products may result. Thus, supplies with a low chlorine demand do not develop objectionable odors, and, as a result, plant control is easier and expenditures on chemicals are kept to a minimum.

Causes of odor problems at any given water plant must be determined locally and on an area basis. A technique for making an odor survey is available. With a knowledge of sources of odors of different characteristics, causes of difficulties can be defined. Industries and municipalities that are sources of odorous material or material of high chlorine demand must provide facilities for treatment, disposal or recovery, or controlled discharge at such a low rate that no odor problems develop. Controlled discharge will eliminate most odor problems.

Characteristics and effects of each odorous discharge should be determined. Some discharges of highest odor intensity have little effect downstream because the odors are volatile and disappear quickly. Other odors of much lower intensity persist. Thus, across-the-board regulations on odor intensity will not be effective. Requirements must be developed on an area basis.

Full recognition must be given to taste and odor problems resulting from so-called natural sources: decaying vegetation, surface wash (from runoff), and algae. Problems caused by algae will continue to increase. Sew-

age treatment plants, particularly those employing biologic treatment, have promoted nitrification of sewage, and discharging such sewage from a large area to one point in a river can increase the nitrate concentration and promote the growth of algal blooms. Algal blooms and odor problems are promoted also by the phosphorus in detergents. High-level dams will add to the problems by increasing the nitrate and phosphate concentrations, particularly where municipal supplies and discharges are in the same pool.

Water plant operators must realize that odor determinations done according to proper procedure will be helpful. Too frequently the odor data at water plants are useless. The first objective in the elimination of odors is the removal of slug discharges. Then it can be determined whether additional treatment is required. If so, the requirements for reducing overall odor should be determined, as opposed to setting limits on individual compounds. A percentage reduction for any given compound is not certain protection against odors.

These recommendations offer no easy panacea for all taste and odor difficulties. Nor do they offer easily administered limits for objectionable materials. The recommendations, based on accomplishments, are offered to point out that a concerted effort in a particular area can reduce, if not eliminate, sporadic taste and odor difficulties in a relatively short time at a minimum cost, and without the necessity of controversial standards or complicated analyses.

Summary

Studies that started in 1953 at the Beaver Falls water plant and on the Mahoning-Beaver rivers have provided proof that a limiting concentra-

tion on phenol will not insure that a water supply is protected against taste and odor. Instead, to achieve that protection, taste and odor must be considered as entities and all sources of odorous material controlled.

The conclusions are based on laboratory studies and proved by plant operating records. They are the result of studies that have added to the understanding of the role of phenol in creating taste and odor, and the importance of other organics in all taste and odor occurrences.

It was found in these studies that increasing a normal discharge of 100 lb/day of phenol to the river above the water intake to 3,600 lb/day caused no trouble. Rather, taste and odor incidents were traced to cleanout of

organics low in phenol concentration but high in odor intensity and chlorine demand.

These findings were submitted in interim reports by the author to Youngstown Sheet & Tube Co., and Republic Steel Corp. The reports are: "Relationship of Phenol Concentrations to Taste and Odor Thresholds" (May 25, 1955); "Phenol Concentrations at Ohio-Pennsylvania State Line Related to Phenol Concentration and Odor at Beaver Falls and Influence of Flow Conditions" (Dec. 15, 1955); "Odor Threshold Survey on the Mahoning-Beaver Rivers" (Mar. 9, 1956); "Role of Phenol in Taste and Odor Control" (Mar. 25, 1957); and "Phenol, Chlorine, and Odor Relationships" (Jan. 1958).

Discussion

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Ettinger and Ruchhoft¹ described the destruction of phenol and cresols added to surface waters, and studied the factors governing the behavior of these materials therein. Biologic oxidation was found to be the principal cause of the destruction. Under favorable conditions, phenol destruction was complete in a relatively short time. At least six factors affected the metabolic rates of the organisms destroying the phenolic materials: temperature, metabolic lag, the nature of the initial microbiologic population of the water, the concentration of the phenolic compound, the specific phenolic compound involved, and the presence of such

nutrients as nitrogen and phosphorus to permit utilization of the phenolic material in microbiologic metabolism.

Conditions in the Mahoning River are usually conducive to optimum rates of phenol assimilation. The river, as noted by the Ohio River survey² and reaffirmed by Kinney, requires a combination of cold weather and increased runoff to move substantial amounts of phenol downstream.

Phenols and Water Quality

Phenol is an indicator of unsatisfactory water quality. Normally, phenols do not occur in raw water in any substantial amount, unless the water is polluted by phenolic wastes in the immediate vicinity or conditions are favorable for the travel of pollutants, which undergo self-purification readily. Phenols do not travel efficiently in streams, but they usually occur along

with a great deal of other and frequently more persistent organic pollutants. Further, phenols usually occur in highly industrialized areas where pollution from other sources also enters the river. Phenols may be regarded as both a direct impairment of water quality and an indicator that stream self-purification processes are inadequate to protect water supplies from chemicals entering the stream—that is, stream purification is inadequate to give good reduction in pollution between the water plant and the phenol source.

It is not surprising to find a correlation between phenol content in raw waters and severe problems of water quality. It does not follow, however, that water quality problems will be greatly improved simply as the result of reduction or removal of phenolic contamination, even though the phenolic pollution constitutes a well defined water quality impairment. In practice, it is difficult to remove phenols without affording some relief from pollution by other chemicals that accompany the phenols. There are no reports of a water supply that contained a lot of phenol but was otherwise of good quality.

Recent work by Burttschell and associates³ at the Robert A. Taft Sanitary Engineering Center in Cincinnati has done much to chart the reaction pathway in the production of taste and odor during the chlorination of phenol. When chlorinated, phenol was found to yield the normal chlorination products predictable from a general knowledge of organic chemistry. Previously overlooked, 2,6-dichlorophenol was found to have the most intense taste and odor. The principal sources of taste and odor are, in order of importance: 2,6-dichlorophenol, 2-chlorophenol, and 2,4-

dichlorophenol. The last, however, was not perceived in low concentrations by one worker. At threshold odor, the geometric mean concentration of these chemicals detectable in distilled water was found to be: 2,6-dichlorophenol, 2 ppb; 2-chlorophenol, 4 ppb; and 2,4-dichlorophenol, 8 ppb.

At low pH values, rates of chlorination of phenol are very low. The previous multiplicity of observations^{4,5} that the application of ammonia prior to chlorination was capable of eliminating or markedly reducing chlorophenolic tastes was further explored. More evidence of the soundness of this observation was obtained, and, in some circumstances, periods of 2 days and longer were noted before intense taste and odor developed, although mild taste and odor could be observed earlier.

The complex interrelationships pertaining to the development of tastes when chlorine is added to waters containing both ammonia and phenols have not been fully studied. The writer takes some satisfaction from the knowledge that further study of the kinetics of phenol chlorination is planned by J. Carrell Morris at Harvard University.

Beaver Falls Experiment

The writer's conclusions from the data on the Beaver Falls experiment are not the same as those reached by Kinney. As a frame of reference, an examination might be made of the data obtained at Chanute, Kan., during the period, Oct. 14, 1956—Mar. 14, 1957, when the city was obliged to augment its water supply by recirculation of its treated and lagooned sewage as a principal source of raw water.⁶ It is estimated that the water was reused about ten times. The odor of the raw and finished water was observed thir-

teen times at the water plant during the period Jan. 12–Mar. 19, 1957, by an observer known to have better than average odor perception. The median threshold odor of the raw water was 4, with a maximum of 16. Because of the huge quantities of ammonia present in the raw water, and because of the limitations of the plant's chlorine feeder capacity, a combined chlorine residual was all that could be obtained. Other special measures for taste and odor control were not applied. The finished water was reported to have a poorer odor quality than the raw water, with a maximum threshold odor of 16 and a median threshold odor of 8. Minimum threshold odor on both raw and finished water was 2.

With these data in mind, an examination should be made of the Beaver Falls data for the period Feb. 21–Mar. 6, 1957, when Kinney was attempting to demonstrate that phenolic discharges are not an element of water quality. The last of the interim reports mentioned in Kinney's summary states that the threshold odor of the raw water was 250 nineteen times, and 125 two times. The threshold odor of the finished water was 25 four times at the start, increasing to 50, which was the reading with the exception of a threshold odor of 83 on February 28. Although it is possible to argue about the dominant characteristic of the odor, no one could present much of a case that the water was potable. If slugs caused the water qualities noted, they must have been continuous. Kinney, however, has stated that there were no slug discharges during this period.

The river must have assimilated large quantities of phenols during the period of observation. This great ca-

capacity for self-purification must have equally affected sewage pollution. It is difficult to understand, especially after referring to the Chanute data, how taste and odor of the magnitude reported could have resulted from any source other than industrial discharges.

The situation considered appears to be ill-chosen, if it is desired to determine whether phenols alone are a significant contributor to taste and odor problems in water supplies. The data presented describe a highly unsatisfactory water during the entire period of maximum phenol discharges to the river. The fraction of the odor distress that was directly attributable to phenol is a matter for conjecture.

When a situation resulting in a finished water with a median threshold odor of 50 is offered as proof that phenolic pollution is innocuous, there are no grounds to consider further the details of the thesis presented.

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Having had the opportunity to read not only the article but also the several reports mentioned in the author's summary, the writer feels that the data collected over a 4-year period amply support the author's conclusion that there is no correlation between the phenol concentration in raw water and the occurrence of medicinal odor at water treatment plants. The same conclusion has been reached by other investigators, but it was based on much less extensive work and therefore was regarded with skepticism in some quarters.

Orsanco Findings

The findings of the survey reported by the author have been criticized on the basis that the Mahoning River is not typical, and that consequently there is no reason to assume that phenol is not a major factor in causing medicinal odor elsewhere. The Water Users Committee of the Ohio River Valley Water Sanitation Commission (Orsanco) cooperated in an investigation of the relationship between phenol concentrations in raw water and medicinal odors in finished water. Daily samples were analyzed for phenol and odor threshold at water plants on the Allegheny-Monongahela-Ohio river systems. Of 933 samples of raw water containing phenol concentrations ranging from zero to more than 200 ppb, there were 34 instances in which a medicinal odor occurred in the finished water. Interestingly, a medicinal odor was found in one finished water when the raw water contained no phenol.

This work also showed that there was no correlation between odor and phenol concentration.

Other Findings

The complaint that phenol from by-product coke plants is a major factor in causing unpleasant taste and odor in drinking water apparently stems from two related circumstances. During the 1920's, the still waste from all the coke plants on the Ohio River was discharged without treatment. Public water supplies of communities along the river were almost always bad tasting. State agencies urged the steel industry to cooperate in correcting the condition, and, after installation of dephenolizers, bad tastes and odors practically disappeared. This was a logical instance of cause and effect, which pointed to still waste as the primary factor in causing taste and odor in water.

About the same time, USPHS found that the addition of chlorine to a solution of pure phenol caused a medicinal odor that could be detected in concentrations of 5 ppb or less. This laboratory work, coupled with the improvement in water quality following dephenolization of still waste, appeared to offer irrefutable proof that minute amounts of phenol always caused a bad taste in drinking water. Apparently, this finding of USPHS is the source of various state regulations limiting phenolic compounds in waste water to 5 ppb. The Pennsylvania Sanitary Water Board was even more cautious; it required complete elimination of phenolic substances from waste water.

The requirements governing discharge of phenolic material were quite proper when they were made, because

the evidence then available linked taste and odor problems to phenol. A great deal of information now at hand demonstrates clearly that phenol is but one of many categories of compounds that can impart an unpleasant taste to water. The old regulations continue to stand, however, because the new information has not been formally recognized.

Natural Sources of Phenol

The most significant of recent data illustrate the role of the processes of natural decay as sources of a variety of odorous substances, and that phenols are prominent among them. As a result of reports that virgin streams normally contain 5–20 ppb of phenol and that knowledge of the amount of phenolic material in the Ohio River was meager, the Steel Industry Committee of Orsanco conducted a 2-year phenol survey of the Monongahela and Ohio rivers. The cooperating companies collected cross-sectional samples every week at nineteen points covering 112 mi of river from Monessen, Pa., to Wheeling, W.Va. The known discharge of coke plant phenol was about 4,000 lb/day, yet loads of 10,000–25,000 lb/day were found after rainfall runoff. Phenol concentrations as large as 400 ppb were found on occasion, but there were no reports of unusual taste and odor difficulties at water plants. This survey provided presumptive evidence that large amounts of phenolic substances were coming from nonindustrial sources.

The fellowship sponsored by the American Iron & Steel Institute at the Mellon Institute has been making a fundamental study of the natural origin of tastes and odors. It has been suspected that tannins yield phenols in the course of biochemical decay, and

the fellowship has been studying the generation of byproducts as oak leaves decay. A number of fermentations have been made, and a surprising amount of phenolic material has been produced. In a current study, oak leaves were suspended in river water and samples withdrawn for phenol analysis at intervals. In 10 days, the phenol concentration was 1,250 ppb; a month later it was 1,460 ppb. It is easy to visualize this process occurring in natural pools, thus providing an explanation for the increased load of phenols in rivers after a rainfall.

The possible effect of these natural phenols on the taste of drinking water was studied by chlorinating samples of the infusion. In one series, the infusion was diluted with phenol-free water to a phenol concentration range of 20–260 ppb. On addition of chlorine to the breakpoint, medicinal odors developed with thresholds as high as 500. The chlorine to phenol ratio was about 1,000:1. This would seem to support Powers' finding that the chlorine driving-force needed to cause a reaction rises very rapidly as phenol concentrations decrease. On the other hand, the oak-leaf infusion evidently had a high chlorine demand, and the large excess of chlorine required may mean that it first reacted with nonphenolic material. This is borne out by the fact that the breakpoint had to be reached or exceeded before a medicinal odor would occur.

In another series, the pH of two sets of samples was adjusted to about 6.5. Lime water was used in one set, sodium bicarbonate in the other. When the same procedure was used as before, a medicinal odor was detected in samples to which bicarbonate was added, but not in lime-treated samples.

This effect was observed in earlier work and suggests that dissolved solids may influence organoleptic properties.

If the theory of natural generation of phenols were true, it could be reasoned that the organic matter deposited in large reservoirs would transfer phenols to the overlying water. Four large reservoirs were sampled a number of times in the winter of 1958. Phenol concentrations were quite low, in a range of 0-7 ppb. On the other hand, the superintendent of the Wilksburg-Penn Joint Water Authority has repeatedly detected medicinal odors after a heavy runoff from rainfall or from the drawdown of a reservoir on the Allegheny watershed. The Mellon Institute Fellowship was notified in April 1958 that plans had been made to open the gates at Piney Reservoir to relieve the pressure of heavy local rains above Clarion, Pa. Samples were collected from the Clarion River at several points, before and after the gates were opened. About 3 mi below the reservoir, the phenol concentration increased from an average of 7 ppb to an average of 16 ppb, with a maximum of 25 ppb. Arrangements were made for collection of samples at Wilksburg, Pa., every 4 hr following marginal prechlorination. The samples were analyzed for phenol in the fellowship laboratory; odor thresholds were measured by the Wilksburg operators in accordance with their regular routine. Phenol concentrations were low, in a range of 0-6 ppb, until, 62 hr after the reservoir gates were opened, a sample registered 65 ppb. On 4 of the 5 days preceding the drawdown, the odor thresholds

ranged from 8 to 16 and were characterized as "woody, medicinal"; during the period when the high phenol concentration was found, the threshold was 14, and the odor was called "woody, sewage."

In 1957, the writer discussed tastes and odors in drinking water with representatives of 17 western state health departments. It was universally agreed that decay of vegetation was the principal cause of bad-tasting water. There were a number of instances of medicinal tastes at water plants on virgin streams where the only treatment was chlorination. Differences in the biochemical decay of vegetal matter in the West and in the East are not likely to be great. It is thus unfortunate that the part played by natural processes has never been properly evaluated.

Conclusion

The data reported by the author and the writer show clearly that many more factors than phenol concentration are responsible for bad taste in drinking water. This is a complex subject on which basic research is in progress in a number of laboratories. It seems reasonably obvious that corrective measures cannot be taken until the causative factors have been identified. This is an extremely difficult research project, largely because of the lack of analytic techniques of adequate specificity and sensitivity. Progress is being made slowly but steadily, and it is safe to say that this problem, like others that at first seemed insoluble, will eventually be solved.

Report on Publications

—For the Year Ending December 31, 1959—

A report on the publishing activities of the Association for the year ending Dec. 31, 1959, submitted to the AWWA Board of Directors on Jan. 26, 1960, by Eric F. Johnson, Director of Publications.

TWO new manuals—on management and meters—were the features of the publications list during the year. The JOURNAL pushed its advertising income to a new high, even above the optimistic estimate of last January. A more useful Reference Directory not only paid for itself but for the loss sustained by the 1958 Membership List Edition as well. *Willing Water* finished its first full year as a monthly, having become the voice of "Advancement," as well as the medium for news of Association affairs. Sales of books and manuals took a sizable jump as a result of direct-mail advertising. And, even without promotion, sales of public relations booklets almost doubled.

Toward the future, the manuscript for the eleventh edition of *Standard Methods* was completed, first steps were taken to revise the *Accounting Manual* and *Water Quality and Treatment*, the manuscript for the new distribution manual was all but completed, and plans for a number of other titles in the soft-cover "manual" series were being considered.

1. The Journal

A detailed picture of JOURNAL contents, costs, and income for the past 5 years is presented in Tables 1 and 2.

a. Contents. Despite the fact that text pages fell a little below the 1,650 goal, total pages in the 1959 JOURNAL

were 32 more than planned. Responsible for this apparent anomaly was the fact that not all the reductions in the Percolation & Runoff section contemplated as being necessary to meet budget demands had to be made. Actually some space economies were introduced, with the result that 11 pages of additional advertising and 13 more pages of abstracts were accommodated in less space than required for the section in 1958, but no drastic cuts were made.

As far as the analysis of text articles is concerned, it should be pointed out that the reduction in overall number of papers, as well as in section papers, is partly accounted for by the increasing use of the longer panel discussions. It is true, too, that contributions prepared specifically for publication rather than oral presentation tend to be longer than meeting papers, and there was a significantly higher proportion of these in 1959.

b. Costs. The significant increase in costs during 1959, despite the smaller JOURNAL, is the direct result of a 12.7 per cent increase in printing prices imposed in December 1958. Even though higher, these costs were more than \$4,000 below budget estimates, partly because print orders were smaller than had been expected, a result of the temporarily arrested growth of the Association.

c. Income. Reflecting the first full year under an increased rate, as well as a slight increase in pages sold, advertising income rose significantly. Similarly, subscription income jumped with an increase in subscription rates.

Based on its consideration of the very low cost of JOURNAL advertising

compared with that in other publications in the field, and of the increased financial obligations of the Association, the Executive Committee in September took action to initiate a 25 per cent increase in JOURNAL advertising rates.

d. The future. For 1960 a JOURNAL of 1,650 text pages and 1,358 Percola-

TABLE 1
Journal Contents, Costs, and Income, 1955-59

Item	1955	1956	1957	1958	1959
<i>Contents</i>					
Text pages	1,262	1,618	1,646	1,682	1,620
P&R pages	1,282	1,262	1,426	1,390	1,388
<i>Total pages</i>	<u>2,544</u>	<u>2,880</u>	<u>3,072</u>	<u>3,072</u>	<u>3,008</u>
<i>Text articles:</i>					
Conference papers	23	54	28	41	24
Section papers	90	60	83	92	64
Contributions	19	50	33	46	68
Reports & official documents	13	15	17	25	15
<i>Total articles</i>	<u>145</u>	<u>179</u>	<u>161</u>	<u>204</u>	<u>171</u>
Abstract pages	72	55	100	99	112
<i>Costs*</i>					
Production	\$ 5,303	\$ 8,144	\$ 7,505	\$ 7,623	\$ 7,079
Printing	47,217	55,266	64,238	65,991	73,537
Paper	15,232	19,033	23,284	25,030	25,154
<i>Total costs</i>	<u>\$67,752</u>	<u>\$82,443</u>	<u>\$95,027</u>	<u>\$98,644</u>	<u>\$105,770</u>
Total-cost index†	102.7	125.2	143.9	149.4	160.1
Cost per copy	45.9¢	53.0¢	57.0¢	56.0¢	59.3¢
Cost per 1,000 pages	\$ 2.13	\$ 2.17	\$ 2.19	\$ 2.15	\$ 2.33
Printing rate index†	101.9	102.5	108.7	109.9	122.5
Paper rate index†	104.1	110.1	118.2	120.4	122.2
<i>Income</i>					
Advertising	\$107,209	\$115,816	\$124,889	\$131,988	\$138,122*
Subscriptions	\$ 9,172	\$ 9,879	\$ 10,946	\$ 11,788	\$ 15,048
Total pages paid advertising	969	987	1,092	1,040	1,051
Advertising rate index†	109.4	117.7	117.7	129.4	129.4
Rate per 1,000 circulation	\$ 8.17	\$ 8.34	\$ 7.94	\$ 8.27	\$ 8.33
Circulation (avg paid per issue)	11,281	11,844	12,639	13,316	13,215
Circulation index†	110.2	115.6	123.4	130.1	129.0

* At variance with audit figures because of different basis.
† 1953 = 100.

tion & Runoff pages is being planned. Expecting a circulation increase of approximately 1,000 during the year and no significant increases in prices, at least until the last month or two of the year, the staff has estimated its costs at \$111,500. And, although most of the yield from its higher advertising rates, which become effective on new contracts beginning in March, will not be realized until 1961, an advertising income of \$150,000 has been forecast. The optimism is based partly on the favorable outlook for business during the year and partly on the expected

which turned out to be even more popular than predicted. The result was that advertising income exceeded estimates by 22 per cent. And, with the elimination of the expensive listing of "New Members" (now included monthly in *Willing Water*), cost of the Directory was actually brought down below that of the 1957 edition, and 15 per cent below budget estimates. Instead of an expected \$500, net income was more than \$5,000.

In 1960 the Membership List Edition will again be issued, expected to cost \$15,500 and to bring in an income of \$10,000. Some members question the necessity of this expensive publication, but there seem to be enough who find it valuable to require its continuation. Less expensive means of producing it through new types of photographic equipment are being investigated and may soon afford a means whereby the gap between income and outgo may be, at least, reduced. Meanwhile, the Reference Edition, which was originally published with the membership lists, has reached the point where it is earning in the odd years what the Membership List Edition loses in the even years.

TABLE 2

Relation of Journal Cost to Advertising Income, 1955-60

Year	Total Cost \$	Advertising Income \$	Dollar Spread \$	Percentage Spread %
1955	67,752	107,209	34,457	58.2
1956	82,442	115,816	33,374	40.4
1957	95,034	124,889	29,855	31.5
1958	98,644	131,988	33,344	34.0
1959	105,770	138,122	32,352	30.6
1960*	111,500	150,000	38,500	34.5

* Budget figures.

results of some additional advertising promotion.

2. The Directory

A new feature included in the Reference Edition of the Directory in 1959 resulted in not only a more useful volume but the first significant net income to be earned by this publication since its introduction in 1953 (see Table 3). Added to the Association reference material, committee lists, consultants directory, water supply library, and buyers' guide that have made up past Reference Editions was a paid listing of Associate Member branch offices and representatives,

3. Standards and Reprints

During 1960 the standard for gate valves (C500) was completely revised and new standards were issued for sodium aluminate (B405) and liquid alum (incorporated into the existing aluminum sulfate standard, B403). These were published in the JOURNAL and subsequently made available as separate documents.

Sales of standards during the year totaled \$14,900, compared with \$12,500 in 1958. Meanwhile reprint sales, no doubt reflecting the reduction in articles printed, dropped slightly from

\$8,600 in 1958 to \$8,300 in 1959. Costs involved were \$8,000 for standards and \$6,400 for reprints.

4. Willing Water

As indicated earlier, *Willing Water* changed character in 1959, becoming not only an information channel for the Advancement Program, but a regular medium for dissemination of Association news and publicity. Beginning with the March issue, it included a 4-page blue-paper section devoted to "Advancement" activities and news. In the balance of its pages, in addition

cent. A 15 per cent increase in mailing costs during the year and the inclusion of four extra pages in one issue were primarily responsible for the added expense.

Actually, it appears now that the 16-page issues originally planned could profitably be used at least half the time, but 1960 budget considerations have indicated the desirability of holding the cost to \$18,000, which, on present terms, will require limiting the issues to their 1959 size. It is hoped, however, that a shift to a different type of addressing procedure and the elimination of the envelope now used in the mailing may make possible significant savings in mailing costs and thereby stretch the \$18,000 to cover at least 160 pages.

Another prospect, to which consideration is being given at the request of the Executive Committee, is that of selling advertising space in the pages of *Willing Water*. A major objection to the idea is that it would reduce the impact of the information published, in increasing the size and content of the publication. Although it has been suggested that the growth could be limited by limiting the advertising to members who hold twelve-time JOURNAL advertising contracts and, even beyond that, by limiting their eligibility to specified issues during the year, it is feared that the administration of such a complicated program would be costly in both employee time and advertiser good will. As the purpose of the Executive Committee's suggestion could best be served by accepting advertising on an unlimited basis, it is possible that the best answer would be to convert *Willing Water* into a full-fledged second monthly magazine, on the order of *Civil Engineering* or *Chemical & Engineering News*. Such

TABLE 3
Comparative Data on Directory Reference
Editions, 1953-59

Item	1953	1955	1957	1959
Total pages	136	176	192	192
Number of copies printed	12,330	13,990	15,901	15,647
Total cost	\$4,416	\$5,893	\$7,384	\$7,157
Cost per 1,000 pages	\$2.56	\$2.34	\$2.37	\$2.33
Cost per copy	35.8¢	42.1¢	46.4¢	45.7¢
Total pages paid advertising	44	57	64	85
Advertising income	\$3,841	\$6,266	\$7,397	\$12,229
Net cost per copy	4.7¢	-2.7¢	-0.1¢	-32.4¢

to three conference papers, six section papers, and four contributions, it included monthly lists of new members and new life members, section meeting reports, conference publicity, reports of Board and Executive Committee meetings, and a variety of other Association news and features. As it develops this publication pattern, *Willing Water* will undoubtedly become a more and more valuable means of communicating with members.

Total cost of producing and distributing 148 pages of *Willing Water* during 1959 was \$17,406, which exceeded the \$16,000 budget by almost 9 per

a conversion could not be made overnight, of course, but if it is thought desirable, plans should be drawn now and the necessary investigation and reorganization accomplished in an orderly manner.

5. Booklets and Public Relations Aids

Almost half a million of AWWA's public relations booklets were sold during 1959 in a demonstration of the continued interest in these public relations aids, whose sales, cost, and income totals are given in Table 4. Meanwhile, other items in the public relations catalog—and particularly the Willing Water novelties—also increased in popularity.

129,500 from only 46,000 in 1958, putting total sales of this booklet, too, over the million mark. As it contains no information that will become obsolete, *Your Water Supply* should continue to be a useful tool for members and a bestseller for AWWA for years to come.

c. What Price Water? A useful booklet, but one that has never attained the popularity of either of the others, *What Price Water?* sold only 12,300 copies in 1959, compared with 40,000 in 1958. With an inventory of only 10,500 copies at the end of the year, it is expected that the booklet will have to be reprinted during 1960. As long as income exceeds cost and

TABLE 4

Summary Data on Public Relations Booklets Through 1959

Booklet	No. Printed	No. Sold	Inventory	Production & Sales Expense \$	Income \$	Inventory Value \$
<i>Story of Water Supply</i>	1,800,000	1,628,500	171,500	42,467.20	67,125.52	3,104.15
<i>Your Water Supply</i>	1,081,700	1,049,900	31,800	17,314.94	26,625.96	411.81
<i>What Price Water?</i>	100,000	89,500	10,500	2,953.74	3,378.43	179.34

a. The Story of Water Supply. After dropping below 200,000 in 1958, sales of *The Story of Water Supply* jumped to a record high of 332,800 in 1959, accomplishing this increase without any special promotion. Actually, it had been expected to make some slight changes in the statistical information included in this booklet before reprinting, but a rush order at the time made it undesirable to delay the run. Before the next printing, which is expected in the summer of 1960, consumption figures, particularly, will be reviewed for possible revision.

b. Your Water Supply. Also without special promotion, sales of *Your Water Supply* in 1959 jumped to

the book continues to serve a useful purpose, it will be continued in print.

d. Sound slide film. Introduced in 1958, the slide film version of *The Story of Water Supply* has not been as popular as was expected, although, priced at \$35 per copy, it seems that any water utility should be able to afford a copy. Sales during 1959 totaled 43 copies, compared with 34 copies in 1958. With the cooperation of the producer, further promotion will be given to this item in 1960.

e. Other public relations aids. Among the other public relations aids offered by the Association—newspaper mats and electrotypes, posters, postal meter ads, decalcomanias, and novelty

jewelry—it was the Willing Water jewelry that drew most attention during 1959. Publicized by the souvenir lapel pin given to each registrant at the 1959 Conference and by the display kits sent around to several sections, the jewelry items doubled 1958 sales, reaching a total of \$2,100. Included in this total were a number of new Willing Water service pins, as several additional utilities adopted this method of recognizing employee tenure.

During 1960 an effort will be made to publicize the jewelry items further through the use of display kits at section meetings and, possibly, through some convention favor. Meanwhile, the Indiana Section is planning to stock and sell the lapel emblems at its meeting in an effort to promote use of the symbol. [A total of 200 was actually sold at the meeting.]

During 1960, too, it is expected, finally, to develop the Willing Water truck decal which was mentioned last year. Correspondence with a number of utilities has indicated that such an item could be sold in sufficient quantity to pay the cost of development, and the Executive Committee has recommended that the necessary funds to undertake the project be made available from the publications budget.

6. Books

Early in 1959 a direct-mail sales sheet listing AWWA books and manuals was distributed to members. The response as usual was very noticeable, sales of all items included increasing significantly. Full financial and sales data on the five books published by the Association are included in Table 5, the data on 1959 sales being given in the review that follows:

a. Manual of Water Works Accounting. Sales: 71 copies in 1959; 46 in 1958; 118 in 1957; 87 in 1956.

At the moment, with a new committee being formed to consider its revision, reprinting is not being planned. But the Municipal Finance Officers Association, copublisher of the book, has offered to make some of its copies available if AWWA's stock is exhausted before a new volume is ready.

Formation of the AWWA committee has been delayed by the inability of the selected chairman to take on the job. Meanwhile, the MFOA has appointed its committee and will be ready to cooperate.

b. Survival and Retirement Experience With Water Works Facilities. Sales: 126 copies in 1959; 30 in 1958; 105 in 1957; 43 in 1956.

c. The Quest for Pure Water. Sales: 111 copies in 1959; 53 in 1958; 97 in 1957; 48 in 1956.

In binding the balance of the unbound sheets during 1959, the Association obtained a bonus of 120 copies, the sheets totaling 611 copies instead of the 491 that had been carried on the inventory. When the 647 copies now in stock are sold, the book will be out of print.

d. Water Quality and Treatment. Sales: 614 copies in 1959; 430 in 1958; 482 in 1957; 423 in 1956.

With sales continuing at a high level, another binding of this volume will be necessary during 1960; at that time enough copies should be bound to take care of demand until the third edition of the book is ready.

Plans for a third edition are now definitely under way, with Charles A. Black, chairman of the Water Purification Division, in process of forming a review and revision committee. Current plans call for appointing a sub-

committee chairman to review each chapter and then, depending upon the amount of revision required, do the work of revision himself or with a group. On this basis, it will probably be 1962 before the third edition can be issued.

e. Index to Journal AWWA (1940-55). Sales: 318 copies in 1959; 102 in 1958; 664 in 1957.

Sales of this book, particularly, show the effect of promotion. And, as every index sold means many inquiries pre-answered, the staff is particularly eager

1960, to clear up final questions with the editor, and the printer will start work on the typesetting before Mar. 1. Depending upon his production and the cooperation of the Joint Editorial Board and any others called upon to review special sections of the book, it should be possible to issue the eleventh edition during 1960.

AWWA's representative on the Joint Editorial Board is Michael J. Taras, who has done a monumental job of scrutinizing each part of the water section of the book and subject-

TABLE 5
Summary Data on Current AWWA Books and Manuals

Year Published	Book	No. Printed	No. Bound	No. Sold	Inventory		Production & Sales Expense \$	Income \$	Value of Inventory on Hand \$
					Bound	Unbound			
1938	<i>Manual of Accounting</i>	1,898	1,898	1,857	41		3,476.69	6,460.95	61.09
1946	<i>Survival and Retirement</i>	3,006	2,509	2,373	136	490	5,226.25	6,701.99	678.98
1948	<i>Quest for Pure Water</i>	2,632	2,632	1,985	647		9,427.40	8,462.88	1,165.51
1950	<i>Water Quality and Treatment (2nd Edition)</i>	9,300	6,603	6,248	355	2,697	16,601.85	27,177.39	1,838.40
1956	<i>1940-55 Index</i>	3,500	1,500	1,087	413	2,000	4,606.37	4,294.48	1,370.38
	Manual								
1954	<i>Water Rates (M1)</i>	2,200	2,200	2,035	165		1,047.90	2,070.98	38.94
1955	<i>Silent Service (M2)</i>	5,038	2,538	960	1,578	2,500	1,100.41	1,001.37	674.37
1956	<i>Safety Practice (M3)</i>	4,000	4,000	3,233	767		1,916.04	3,722.85	326.74
1959	<i>Management (M5)</i>	3,083	3,083	1,053	2,030		2,920.27	1,546.60	1,725.50
1959	<i>Meters (M6)</i>	2,539	2,539	1,205	1,334		818.34	1,071.13	426.88

to see this volume sell. The 1881-1939 *Index* was sold out during the year.

f. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. Sales of the tenth edition during 1959 totaled 2,800 copies, bringing total distribution of that edition to approximately 20,800 in the 5 years since its publication, compared with sales of 22,000 copies of the ninth edition in 9 years.

The manuscript of the eleventh edition is now almost completely edited. The Joint Editorial Board scheduled a meeting during the week of Jan. 18,

ing it to review and revision by the best informed men in the field. To judge by his efforts alone, the book will be a very decided improvement over the edition now current.

7. Manuals

As noted earlier, two new manuals were issued during 1959—the Management Manual in April and the Meter Manual in November—to fortify this section of the Association's publications list. All but the Meter Manual were included in the direct-mail promotion, the results of which will be

noted in the sales figures reported below. (Full sales and financial data on the five manuals now in print are provided in Table 5.)

a. Water Rates Manual. Sales: 501 copies in 1959; 203 in 1958; 476 in 1957; 167 in 1956. A new printing of this manual will be required in 1960.

b. Silent Service Is Not Enough! Sales: 273 copies in 1959; 73 in 1958; 259 in 1957; 43 in 1956.

c. Safety Practice Manual. Sales: 648 copies in 1959; 857 in 1958; 738 in 1957; 990 in 1956. Even without the special effort in selling the manual at section meetings as in 1958, the 1959 sales remained gratifyingly high, reflecting the continued development of water utility safety-mindedness.

d. Management Manual. Sales: 1,053 copies.

Completed in April, this 192-page manual in the education series is being sold at \$2 per copy, with special discounts for classroom quantities. In its first months it has enjoyed an enthusiastic reception and, with its adoption as a text for the management courses to be sponsored by the Advancement Program, it should gain wide distribution. Prepared by a group of 23 specialists in the various branches of management, it provides a useful reference volume as well as a text.

e. Meter Manual. Sales: 1,205 copies.

Completed as a separate document in November, this 88-page manual covering selection, installation, testing, and maintenance of water meters was first serialized in the JOURNAL, from June through September 1959. Its appearance there and the interest of the meter manufacturers created a strong prepublication demand for it, so that even though it was in existence for less

than 2 months of 1959, its sales topped those of all other manuals.

Both the quality and the importance of this manual are attested by the fact that James G. Carns Jr., chairman and chief workhorse of the committee that prepared it, has been selected to receive the AWWA Publications Award for 1959.

f. Education manuals. Of the three remaining in-service training manuals scheduled for preparation under the supervision of the AWWA Education Committee, the one on distribution is now expected to be ready for the editors on Feb. 15. As soon as it becomes available, it will be prepared for publication serially in the JOURNAL before being reprinted under a single cover as a manual. Using the JOURNAL staff and time for the work will, of course, speed its appearance in print, as well as making it available to all members without charge.

The manuals on source and on treatment are also nearing completion and can undoubtedly be expedited when production time is available for their publication.

g. Other manuals. Work on the steel pipe manual, which had progressed rapidly in 1958, was suspended during 1959 pending reconsideration by the Water Works Practice Committee. Meanwhile, consideration is being given to the development of a manual on cross-connection control based on material prepared by the Association's committee on that subject and by the California Section. And the manuscript on a manual for the installation of concrete pressure pipe has been virtually completed.

Other manuals are being considered, too, on a variety of subjects that lend themselves better to exposition in the flexible form of paper-covered manuals

than in more permanent hard-covered books.

8. Publication Sales Procedure

During 1959, the continued increase in publication sales and billing and collections finally brought the staff to a point where it could no longer ignore the cost of handling small credit sales. There were other drawbacks to the publication sales procedure, too: the inefficiency and confusion of a multiple-price system; the fact that member municipalities could usually not take advantage of cash-in-advance discounts; the slow service that resulted because of the correspondence and paperwork required on very small orders. To meet these various objections a new system was adopted, effective Jan. 1, 1960. This system involves two basic changes in procedure:

a. Publication discount coupons. To preserve and extend the member discount of 20 per cent for cash, while establishing a single-price basis, a new coupon system has been introduced. Books containing \$10 in coupons which can be used to purchase any item in the AWWA Publications List are available to members at a price of \$8. This means that any member can now, through use of the coupons, ob-

tain discounts on standards and reprints, as well as on books and manuals. It also means that many municipalities that could not previously take advantage of member discounts will be able to, as the coupon books can be ordered and purchased on regular municipal voucher forms.

b. Handling charge. To avoid the losses involved in billing and accounting for small transactions, a handling charge of \$1 is to be added to all non-cash or noncoupon orders of less than \$5. Actually, all purchasers of publications are being warned of the charge by postcard notice and given an opportunity to remit in advance. Thus, no one, member or nonmember, will be forced to pay the handling charge; it is merely a means of *encouraging* the use of cash or coupons on orders that are not worth the price of billing.

[In the short time since the policy has been instituted, it has already been found to speed handling of orders; and some members have already obtained discounts on items that were not discountable in past years. As members become accustomed to the system, it is expected not only to improve service and to afford additional discounts, but to increase sales of AWWA publications.]

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1959

A report of the activities of the Committee on Water Works Administration for the year ending Dec. 31, 1959, submitted to the AWWA Board of Directors on Jan. 25, 1960, by Wendell R. LaDue, Chairman.

AS outlined in the 1959 AWWA *Directory* (Reference Edition), the present organization of the Coordinating Committee on Water Works Administration provides for more than 30 committees and subcommittees, grouped in four classifications, with more than 140 members of the Association participating. The general committee consists of the chairman, the general chairmen of the four groups, and the chairmen of the various active subcommittees. Committee work has been broadened by the creation of "task groups," subordinate to standing committees, and by advisers on research and development committees. Committee activities and personnel have been subject to continual study and changes are effected to suit changing progress of the work. The present committee personnel are:

Committee on Water Works Administration

W. R. LADUE, *Chairman*

L. S. FINCH,	M. P. HATCHER
<i>Vice-Chairman</i>	H. E. HUDSON JR.
L. E. AYRES	J. M. JESTER
J. J. BARR	A. P. KURANZ
E. L. BEAN	R. J. MCLEOD
E. S. COLE	R. S. MILLAR
JOHN G. COPLE	J. H. MURDOCH JR.
G. H. DYER	L. N. THOMPSON
R. J. FAUST	A. A. ULRICH

Inactive Subcommittees

The following subcommittees are now inactive or have not been activated:

4110M—*Constitutional and Statutory Aspects of Municipal Water Utility Organizations*

4150M—*Taxation and Revenue Allocation* (task group active)

4210M—*Public Relations* (now Committee 1140—Water Utility Advancement, of the Board *)

4220M—*Management Relations*

4310M—*Construction Equipment and Material Contracts*

4320M—*Valuation and Depreciation*

4330—*Cost Trends*

4410—*Water Department Reports* (adviser retained)

4420—*Water Rates* (adviser retained)

1959 Conference

At the San Francisco Conference, numerous topics stemming from the Committee's activities provided subject material for the various sessions. Attendance was good and member interest was unusually high. The continuing and growing interest in and importance of the diversified phases of water utility management and admin-

* See report beginning on p. 541.

istration is evidenced by steady flow of inquiries into the Association's headquarters and the several committees regarding activities and findings. Increasing activity is maintained in present fields of the committee's work and expansion is made into other fields as the Association's program, personnel, and budget will permit, and as the membership requires. The present-day problems of administration are increasing in complexity and importance.

Subcommittee Activities

Following is a brief summary of the status of the several subcommittees during the year 1959, as submitted by the committee chairmen:

4120M—Radio and Mobile Communication Facilities for Water Utilities. The survey on the use of shortwave radio facilities, which was begun in 1958, was completed, and a report was submitted during the committee meeting in San Francisco. The committee has no urgent work that should be presented at the 1960 Conference. Stimulation of interest in communication is necessary if water utilities are to retain rights in the use of presently assigned wavelengths.

4121J—National Committee for Utilities Radio. Chairman John M. Jester has been appointed by NCUR as a member of a special subcommittee on mobile relay. The purpose of this committee is to study and make recommendations in connection with two-frequency operation. At a preliminary meeting on Sep. 29, the following points were discussed:

1. Certain utilities, conducting their field operations by certain methods, have an essential necessity for extended range mobile-to-mobile communication.

2. It is not within the province of NCUR to dictate the field operating methods of its member utilities.

3. The FCC recognizes these field operating activities as a substantial requirement for extended range mobile-to-mobile communication.

4. The FCC does not require the applicant to alter his field operating methods to avoid the need for extended mobile-to-mobile communication.

5. The great majority of utilities adapt their complex communication systems to their field operating methods. In aggregate, their combined frequency requirement is greater than the duplex frequency requirement and, therefore, deserves consideration.

Work completed during the year consisted of supplying legal representatives of NCUR with information on the use of coded tones on mobile frequencies as they could be applied for water utility use. Additional information on various phases of shortwave radio and its used by AWWA members has been furnished as requested by the attorneys in connection with their filing of briefs before the FCC in the interest of the power radio group, which included electric, gas, and water utilities. Information on the shortwave radio survey has also been sent to NCUR.

It is suggested that section effort be made to promote more Association interest in the communications field. It is felt that the Association needs closer liaison at NCUR meetings, as well as someone to act as a watchdog in the water utilities' interest. Water utilities may be coming dangerously close to losing their wave allocations.

4130M—Water Used in Air Conditioning and Other Refrigeration. A report of the survey of ordinances and regulations was completed in 1957.

The committee, in general, keeps abreast of developments, which seem to be favorable to reasonable water use.

4140M—Water Use in Fire Prevention and Protection. This committee is at present functioning on a standby basis to observe the effects of the National Board of Fire Underwriters (NBFU) revised rules and regulations. The committee urges that members of the Association review their own situation in the light of the changes, and that members give careful attention to new rating surveys. It is requested that members of the Association who have had surveys made under the NBFU revised rules and regulations send copies of the survey to the committee for its information and review.

4150M—Taxation and Revenue Allocation. Although this committee is not yet active, nevertheless the general office of the Association has had occasion to present to governmental highway agencies the water utility's viewpoint on the important subject of acceptance and allocation of costs and payment of charges due to relocation of facilities proposed by highway authorities. This problem remains constantly before water utility managers, for a stepped-up program of super-highways and turnpikes is developing and continuing to expand, encouraged by current federal and state highway program legislation and implementation. Many states have passed legislation indicating opposite and varying viewpoints on this important subject. It behooves each water utility manager to maintain constant vigilance toward local, state, and national developments.

4160M—American Sanitary Engineering Intersociety Board and 4161J—Joint Committee for Advancement

of Sanitary Engineering. Activities of these groups have resulted in the establishment of the American Academy of Sanitary Engineers. Entrance is by examination in fundamental preparation and proficiency in the various fields of sanitary engineering. More than a thousand engineers have been certified as diplomates of this organization, thus giving public recognition of the profession so closely allied with the water utility field.

4230M—Compensation of Water Utility Personnel. The committee made a study of the compensation of water utility managers in the United States and Canada for the year 1957. A report was presented at the San Francisco Conference and published in the Dec. 1959 JOURNAL. Possibly, reprints of this report should be circulated to the employers of water utility managers, and the committee should make an effort to work with managers in order to assist them in whatever way possible to raise their salaries to the proper level. The committee was also assigned the task of making a survey of fringe benefits in the water utility industry. The activities of this group are of direct personal benefit to the membership.

4240M—Pension and Retirement Plans. A final report based on the questionnaire to water utility managers was published in the November 1959 JOURNAL. State pension systems are still in virtual competition with the Federal Social Security Act. Changing national attitudes toward all types of pension systems will affect the water utility field and is receiving constant attention by this group.

4250M—Safety Practice. The committee is following through on AWWA's safety program. No spe-

cific tasks of any consequence face the committee at the present time, except to keep the program rolling and seeing to it that more utilities participate each year. Section committees are unusually active and aggressive. The record of the safety program continues to grow and the statistical evidence bears out the truth of this statement. In 1958, for example, 990 AWWA safety awards were issued. These awards were given to utilities employing 27,449 people. The injury frequency rate for the group was a low 8.7. In 1953 the US Bureau of Labor Statistics indicated that the injury frequency rate in industry was 22.2. This covered 3,121 utilities. Obviously, the frequency rate for 1958 relates only to the award winners. Nonetheless the results being produced by the safety program are remarkable and a source of pride for everyone that participates. The injury frequency rate dropped from 10.7 in 1957 to a low of 8.7 in 1958. The latter figure was based on an exposure of 55,492,303 man-hr for 27,449 employees. A total of 990 awards was issued in 1958 as compared with 528 in 1957. Thus, in all categories the 1958 record was bigger and better, and the frequency of accidents reduced.

At San Francisco in July 1959 three Wendell R. LaDue Safety Awards were issued. In Class Size 1 (1-9 employees), the award was won by the Jersey Shore (Pa.) Water Co. In Class Size 2 (10-100 employees), the award was won by the Monongahela Valley Water Corp., Elizabeth, Pa. In Class Size 3 (100 employees or more), the award was won by the San Diego (Calif.) Water Department. All produced perfect records. The safety manual has continued to be a best seller of the

Association. It appears that, at last, the water industry has become safety conscious.

4260M—Education. The management manual was produced in 1959, and it is expected that a manual on distribution will be published in 1960. The final draft of the manual on water treatment is expected to be completed during 1960 and published in 1961. It is now proposed to use the management manual as a text for study at management schools.

4270J—Joint Committee on Certification of Water Utility Personnel. This AWWA Committee works with a committee from CSSE in this field of certification. Progress in liaison is reported.

4340M—Water Main Extension Policy. No new developments have materialized this year. Several reports have been published in the JOURNAL. No unusual developments have come to the committee's attention in the last year. A study of the overall problems seems to indicate that practices of individual utilities vary over a rather wide range, and there seems to be a real need for the greater uniformity of practices that will come from a better understanding of matters affecting water main extensions. Much can be gained from the study of case histories.

4430M—Joint Administration of Water and Sewer Facilities. The final report was completed and published in the June 1959 issue of the JOURNAL. With the general acceptance of the sewerage service charge and its almost universal collection by the water utility office, the trend toward joint administration is expanding with attendant problems. It is suggested that the committee be put on an inactive basis with the cochairmen as advisers.

4440M and 4442M—*Residential and Commercial Use of Water*. Processing of peak-demand data will be completed by late winter, and additional data dealing with costs of air conditioning will have been gathered and coordinated with the information now on hand so that a correlation with water rates needed to suppress air-conditioning and lawn-watering peak loads may be possible. This correlation should be completed prior to the 1960 Conference.

The committee would like to prepare a report in essentially final nature on the material it has gathered to date, for presentation at the 1960 Conference. It has been found possible to make some refinement of the material given at the 1959 Conference.

The activation of Committee 4441M may be desirable at this time to round out the problem of water use investigation.

4450D—*Revenue-Producing Water*. This committee is on a standby basis and works closely with the Water Distribution Division.

2210M—*Task Group on Job Classifications*. This is a task group in the province of the Management Division. It is helpful to Committee 4230M (Compensation of Water Utility Personnel). A questionnaire to determine job titles for small organizations was prepared and sent to water utility managers. The review was continued of the job classifications by the Bureau of Employment of the federal government. It is expected that a meeting of the task group will be held at Bal Harbour in order to discuss the work done to date and to orient future work.

2220M—*Task Group on Review and Redevelopment of a Rating Scale for Water Utilities*. The six subgroups,

2221M–2226M, have been very active in preparing statements of standards in the various phases of the problem. It is expected that their individual statements will be completed and in the hands of the task group early in 1960 for consideration.

2230M—*Committee to Cooperate With NARUC Committee on Revision of System of Accounts for Water Utilities*. It may be of interest to report that the Illinois, Maryland, New Jersey, and Virginia commissions have formally adopted the new uniform system of accounts for companies subject to their jurisdiction, all effective as of Jan. 1, 1960. In addition the Rhode Island utility administrator will issue an order adopting the new system as of Jan. 1, 1960. Thus, the original assignment of the committee has been accomplished.

It is recommended that a committee on water utility accounting be formed to study means of insuring that the needs and peculiar problems of water utilities are represented equitably with those of other utilities in the policies and deliberations of regulatory agencies. Such activities would be a natural adjunct to the work of the group presently engaged in revising the accounting manual.

2240M—*Committee to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Service*. The current work of the committee is completed, except to be on the lookout for possible new rules. It is believed that the committee should be kept active so that it may be helpful in keeping Association members informed of developments.

1960 Conference

Topics timely for presentation at the 1960 Bal Harbour Conference are

under discussion by committee members and with others of the Association interested in the Conference sessions, particularly the members of the publication and program committees, and the officers of the several divisions. Many of the best Division programs stem from administrative problems.

Recommendations

The attention of the Board is directed to necessary enlarging of the activities of the Committee on Water Utility Administration from time to time along current lines. There are numerous projects of water utility administration which cannot be handled efficiently strictly on a member-committee basis. They involve a large amount of research and can best be handled as staff projects. The Association's budget can be supplemented by outside funds, especially when a project involves items in which manufacturers or industries are vitally concerned. Such subcommittee activities which might be considered as projects requiring staff aid are:

4110M—Constitutional and Statutory Aspects of Municipal Water Utility Organization (now inactive)

4150M—Taxation and Revenue Allocation (now studying highway changes)

4230M—Compensation of Water Utility Personnel (now underway).

It is the studied aim of the Committee on Water Works Administration to proceed deliberately, acting upon and anticipating obvious member demands and expanding interests, in a long-time policy of continuing and current problems; to maintain close cooperation with the Committee on Water Works Practice and with the Publications Committee; and to encourage obvious member participation in task groups of the divisions. Appreciation is hereby extended to AWWA personnel and to all committee chairmen and committeemen for their many unselfish services. The valued counsel, consideration, and guidance of the members of the Board of Directors are gratefully acknowledged.



Report of the Committee on Water Works Practice

—For the Year Ending December 31, 1959—

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1959, submitted to the AWWA Board of Directors on Jan. 25, 1960, by Louis R. Howson, Chairman.

STANDARDIZATION and research activities of AWWA continued their high level of progress during 1959. One new standard—for sodium aluminate (B405)—was published during the year. Provisions on liquid alum were incorporated in the aluminum sulfate standard (B403), and the long-pending revision of the gate valve document (C500) appeared in print. (Details of other changes are given hereafter.) In the field of research and development, a number of studies neared completion and several new ones were launched.

Perhaps the most outstanding accomplishment of 1959 was the production of the Manual on Water Meters, which was first published serially in the JOURNAL and then as a separate document. The enthusiastic reception the manual has received is a tribute to the efforts of the Meter Committee and, particularly, to Chairman James G. Carns Jr.

Standards

Deep wells. The California Section, acting through an ad hoc committee appointed by the Board, has submitted proposed additions to the deep well standard (A100) covering double-well casings and rotary-drilled gravel-packed wells (copies of the proposed additions

were sent to the Board in December 1959). As the AWWA deep well committee is now inactive, the proposals were transmitted directly to the Water Works Practice Committee, and were forwarded to the National Water Well Assn., a joint sponsor of AWWA A100. The proposals are now under study by both groups.

Turbine pumps. Both the revision of the vertical turbine pump standard (A101) and the new submersible-pump standard, which will constitute Part II of A101, have been set in type and are now in the hands of ASA Committee B58 for final polishing. The document, probably in preprint form, will be submitted to the Board for approval at the 1960 Conference. Committee B58 is now working on a field test code for eventual inclusion as part of the turbine pump standard.

Soda ash. A change in the definition of "apparent density," approved by the Board in 1959, was incorporated into the published standard for soda ash (B201).

Ferric sulfate. The chemical standards subcommittee charged with developing a standard for ferric sulfate encountered some initial difficulty, owing to disagreement among the manufacturers with regard to production processes. This problem has now been

ironed out, and a document is being drafted for early submission, possibly by the date of the 1960 Conference.

Fluoride chemicals. Advisory Committee 7311 P has been given the task of revising the three current fluoride chemical standards (B701, B702, and B703) to provide for free-flowing materials that will permit accurate feeding. After considerable test work, a satisfactory formula for feedability has been developed. It is hoped to submit the revised standards to the Board at the 1960 Conference.

Cast-iron pipe. ASA Committee A21 is now actively reviewing the AWWA-sponsored cast-iron pipe standards issued under ASA procedure in 1953 (AWWA C102, C104, C106, C108, C110, and C111). Among the subjects under consideration are bituminous coatings, single-gasket joints, and allowances for water hammer, as well as the possible expansion of the short-body fittings standard (C110) to include larger sizes.

Steel pipe. Committee 8310 D is now completing two standards, one for all sizes of fabricated steel pipe, the other for mill types in all sizes. The new standards will replace the existing C201 (steel pipe 30 in. and over) and C202 (under 30 in.).

Coal-tar coatings for steel pipe. Several minor revisions to C203, consisting of changes in the designations of ASTM reference standards, have been submitted by Committee 8310 D. These are recommended for approval by the Board. [The Board approved.]

Steel pipe manual. As directed by the Board, comments and criticisms on the steel pipe manual were presented to the chairman of Steel Pipe Committee 8310 D. A draft of proposed revisions was then prepared. These are

under study by the Water Works Practice Committee, and it is expected that recommendations will be made at the 1960 Conference.

Concrete pipe. Committee 8320 D has completed a draft of the proposed concrete pipe installation manual and is engaged in collecting illustrations for it. It is hoped that the document will be ready for presentation to the Board in 1961.

Asbestos-cement pipe. Committee 8340 D, which has the assignment of revising the tentative standard for asbestos-cement pipe (C400), has suggested that this be accomplished in two stages: (1) an interim revision of the current document, based on information now on hand; and (2) the preparation of a new edition, using design data to be developed by special research. The first stage is nearing completion, and it is expected that the proposed changes will be submitted to the Board at the 1960 Conference. At that time also, recommendations will be made regarding the best procedure for carrying out the second stage.

Gate valves. A committee representing the manufacturers of gate valves is preparing a list of suggested amendments to the recently revised standard (C500), which was approved as Tentative by the Board in January 1959 and was published in the July 1959 JOURNAL. When these amendments are formally transmitted to the AWWA Secretary, it is expected that they will be turned over to the appropriate committee for study, after which a report with recommendations will be made to the Board.

Hydrants. The standard for dry-barrel hydrants has been in effect in its present form since 1954. It is recommended that Committee 8510 D be

reactivated to review this document. [The Board approved.]

Meters. Following completion of the Meter Manual (AWWA M6), Committee 8610 D undertook a review of the existing meter standards, beginning with C700 (displacement type). It is hoped that a revision of C700 will be completed during 1960; work on the other documents in the series will then proceed.

Steel tanks. Some minor changes in the steel tank standard (D100) were approved by the Board in 1959 and incorporated into the published document. A few additional changes are now under study by Committee 8710 J and may be submitted for approval during 1960.

Tank painting. The tank painting standard (D102) requires extensive revision to bring it up to date. A draft revision has been prepared by Committee 8710 J, but, owing to the existence of considerable differences of opinion on the highly technical points involved, it may be some months before a final draft can be submitted. [Many of these points are discussed in an article by Chairman Jackson that was published in the February 1960 JOURNAL.]

Research and Development

Artificial ground water recharge. Task Group 2440 R reported at the 1959 Conference and expects to report again at the 1960 Conference.

Underground waste disposal and control. Task Group 2450 R presented a progress report at the 1959 Conference (scheduled for publication in 1960) and is now engaged in collecting data for a subsequent (probably 1961) report.

Chromium and cadmium toxicity. A progress report was presented at the

1959 Conference by Advisory Committee 2610 P. It is expected that the studies of chromium and cadmium toxicity to animals will be completed by the fall of 1960.

Radioactivity testing. Members of Task Group 2630 P assisted in the development of measurement methods for inclusion in the new (eleventh) edition of *Standard Methods*. In 1960 the task group plans to study continuous-monitoring instruments, strontium separation methods, and simplified proximate assay methods for specific radioisotopes, and is considering a resurvey of radioactivity instrumentation and methods employed in water laboratories.

Treatment plant design regulations. Task Group 2650 P is gathering information on state requirements in this field and expects to make a preliminary report at the 1960 Conference.

Synthetic detergents. Task Group 2661 P reported on the effects of synthetic detergents on water supplies at the 1959 Conference (published in the October 1959 JOURNAL). Work on an improved analytical method is now under way at the University of Illinois, under the sponsorship of Task Group 2662 P. It has been pointed out that most of the current research on synthetic detergents is under the auspices of the American Assn. of Soap & Glycerine Producers, whose interests do not necessarily coincide with those of the public water supply field. Accordingly, the chairmen of Task Groups 2661 P and 2662 P have been requested to outline a research program that AWWA might find it desirable to encourage.

Biologic infestation. Task Group 2670 P is gathering data on infestation problems in the expectation of eventually compiling a set of procedures for

dealing with specific organisms. During 1960 the task group plans to provide material for a "question and answer column" to be published in the JOURNAL.

Manganese deposition. Task Group 2680 P is encouraging the investigation of manganese problems along a broad front, as outlined in its report at the 1959 Conference. A paper on "Manganese Removal by Oxidation With Potassium Permanganate," by R. B. Adams, was submitted through the task group chairman for publication in the JOURNAL. [It appears in the February 1960 issue.] A number of other papers are being readied for submission in the near future. The eventual aim is to gather this material into a manual on manganese.

Copper corrosion. With the cooperation of the Copper and Brass Research Assn., a survey of copper tubing in water service has been made. Specimens ranging in age from 12 to 35 years were obtained from a number of cities and turned over to a testing laboratory for analysis. The results of this study will be reported at the 1960 Conference.

Coagulation research. A report was presented by Advisory Committee 2700 P at the 1959 Conference (published in the December 1959 JOURNAL under the byline of Chairman Black).

Diatomite filtration. A pilot plant study comparing pressure with vacuum diatomite filtration of iron-containing water was completed in 1959 and reported on at the 1959 Conference. The results will be used as a guide to further investigations being undertaken at Iowa State University.

Filtrability index test. In the past year the main effort of Task Group 2720 P was devoted to a review and

evaluation of existing methods of determining water filtrability, so as to direct future experimental work into fruitful channels. A progress report, presented at the 1959 Conference, appeared in the December 1959 JOURNAL. Proposed activities for 1960 include: (1) the standardization of a method of expressing overall filter unit performance in order to obtain a suitable yardstick for assessing filtrability test procedures; and (2) experimental determination of the effects of temperature variation on filtrability test results.

Chlorine impurities. Task Group 2740 P reports that methods for determining various substances in chlorine were examined. The existing method for nitrogen trichloride was found satisfactory, but other methods will require further study before they can be finally evaluated. Freezing-point depression as a method for total impurities was studied and shown to be unsatisfactory.

Carrying capacities. The December 1959 JOURNAL article on magnesium hydroxide stabilization is an example of the research being conducted under the supervision of Advisory Committee 2810 D on the effect of treatment methods on water main capacities. A review of results to date, which appear to be leading to important conclusions, will be presented at the 1960 Conference.

Protective coatings. Task Group 2811 D submitted a report at the 1959 Conference (to be published in revised form during 1960). A very satisfactory process for laying down calcium carbonate coatings has been worked out. It is expected that, with another year of research, this project can be brought to the point where it is of practical value.

Other Committee Activities

Chlorine supply. Committee 7330 J, consisting of representatives of AWWA, CSSE, FSIWA, and USPHS, submitted a report in 1959 [published in the January 1960 JOURNAL]. The report covers alum, as well as chlorine, supply for use at water and sewage treatment plants.

Spillway design. Following the dissolution of a joint committee with ASCE, AWWA established its own committee (8120 D) on spillway design and channel capacities about a year ago. Since then the committee has succeeded in obtaining information on more than one-third of the existing water supply dams throughout the United States and is actively following up on the remainder. As soon as the required physical data are assembled, the preparation of a safe design standard will proceed.

Backflow preventers. In its final report (published in the December 1958 JOURNAL), AWWA-CSSE Committee 8210 J—Backflow Preventers recommended the establishment of a new, permanent committee to carry out a number of general tasks, such as the preparation of model cross-connection ordinances and standards. Accordingly, a new committee has been constituted, composed of five representatives each from AWWA and the Conference of State Sanitary Engineers. Ray L. Derby of AWWA has been named chairman. The work of this committee should yield very worthwhile results.

Ion-exchange materials. AWWA has appointed a representative to a task group of ASTM Committee D19 that is concerned with ion-exchange materials. His function is to serve as liai-

son between that group and AWWA's own Task Group 2750 P—Ion Exchanger Test Procedures, so that duplication of effort may be avoided as far as possible. The AWWA task group has been organized, but individual work assignments have not yet been given out to its members.

Standpipes and outside protection. This National Fire Protection Assn. Committee, on which AWWA is represented, has completed its revision of the standard on outside protection, published jointly by NFPA and the National Board of Fire Underwriters. Work on revising related standards is under way.

USPHS "Drinking Water Standards" revision. Subcommittees are hard at work on revision of the various sections on toxicologic and radiologic standards. The possibility of including "recommended" as well as "mandatory" standards is under study. In this connection, it should be noted that AWWA has given Task Group 2220 M—Rating Scale for Water Utilities the assignment of preparing a quality standard for water. The suggestion has been advanced that such a standard might be a useful addendum to the revised USPHS document.

Plastic pipe and fittings. ASA Committee B72 is currently working on three standards for plastic pipe: flexible polyethylene pipe, rigid polyvinyl chloride (PVC) pipe, and solvent-welded cellulose acetate butyrate pipe. Also in preparation—by a subcommittee of ASA Committee B16—are standards for three types of plastic fittings made of acrylonitrile butadiene styrene (ABS). AWWA has representation on both of these committees. In addition, AWWA Committee 8350 D—Plastic Pipe has been estab-

lished to act, for the time being, in an advisory capacity.

Industrial cooling towers. The work of ASA Committee B76, on which AWWA is represented but is not a sponsor, concerns the compatibility of chemicals in cooling water with the materials of cooling-tower construction. The controversial features of the subject have hampered progress so far.

Heat exchangers. The organization of ASA Committee B78 (AWWA is not a sponsor) and its subcommittees

is in process of completion. It is expected that work will be well started before the middle of 1960.

Letter symbols. The subcommittees on letter symbols for mathematics and for pressure vessels have submitted their reports to the parent ASA Committee Y10, which is under ASME sponsorship.

Graphical symbols. ASA Committee Y32 (AWWA not a sponsor) completed work on graphical symbols for welding, which was published as an ASA document in 1959.



Report of the Committee on Water Utility Advancement

—For the Year Ending December 31, 1959—

A report of the Committee on Water Utility Advancement for the year ending Dec. 31, 1959, submitted to the AWWA Board of Directors on Jan. 26, 1960, by James B. Corey, Director of Water Utility Advancement.

THE Water Utility Advancement Committee has attempted, in this report, to indicate the scope of its activities and the activities of the section advancement committees with numerical values. But when the transmission and implementation of ideas are described by numbers alone, some of the major individual efforts expended on the program may be overlooked. In general, however, most of the section advancement committees have accepted material developed by the Association Advancement Committee, implemented it in light of local conditions, and largely improved (although in different ways) the programs the committee has developed to stimulate action.

Management Education

Two sections (Illinois and Indiana) held management education programs in 1958; five (Chesapeake, Illinois, Indiana, New York, and Wisconsin) held them in 1959; and eight (Florida, Illinois, Indiana, Iowa, New Jersey, New York, Southwest, and Wisconsin) are committed to the operation of a management school in 1960. In addition, eighteen other sections have given some consideration to the establishment of a program.

Local Films

Thirty-nine utilities have indicated that local films have been completed, are in the process of completion, or that commitments have been made to produce a film. In an additional 57 utilities, a liaison has been established through the US Junior Chamber of Commerce which, in accordance with the "Priceless Water" film program, may develop into joint efforts in local film making or other worthwhile projects for utilities. Thirty-five communities report that the Junior Chamber is interested in investigating the possibilities of the "Priceless Water" program. One prototype "Priceless Water" film has been provided to each section for the use of its members.

Hometown News

In 1958, two sections (New York and Indiana) operated hometown news programs from section meetings. In 1959, great interest was shown in this activity, in that 23 sections attempted some type of local or hometown coverage, using or adapting the format suggested by the committee. It is anticipated that, in 1960, 29 of 31 section committees will conduct hometown news programs at their section meet-

ings and that these programs will be even more effective because of the experience thus far derived by section committee personnel.

Publicity coverage of the program, attendance, awards, and highlights of the San Francisco Conference was accomplished under the committee's guidance.

AWWA Quarterly

The Association has supplied the section advancement committees, at no charge, with 71,660 copies of our publication "Advancing Your Water Service," directed to mayors and other community decision makers. It advises them of the urgency for business-like utility operation, long-term planning for water facilities, and membership in AWWA. The distribution of this quarterly has been arranged in varying ways by the section committees, although the practice of having the publication distributed by municipal leagues to their members is becoming common. In addition, ten copies of each issue are being made available, without charge, for distribution by the local utility manager to the decision makers in his community. Approximately 1,000 copies of each issue are distributed in this way as a service to members.

Membership Film

The membership promotion film, "What's in It for Us?", utilizing the San Francisco Conference as background, has been shown in 21 sections and has been shown or is scheduled to be shown in 56 districts or water schools, to 40 local decision-making bodies, and to 12 groups of decision makers, such as municipal leagues. One copy of this film has been supplied to each section.

Trade Press

A list of approximately 100 trade magazines or house organs in the water supply field has been compiled, and monthly trade press releases with pictures telling the Advancement Program story have been sent to those on the list. The circulation of all magazines carrying these press releases once or more times was 712,000.

Field Work

Meetings with the section advancement committees (with the exception of the Cuban and New England sections) have been effected by the Director of Water Utility Advancement. In addition, visits have been made to existing or newly established management schools, making a total of 52 separate visits to section meetings, schools, and section executive or advancement committee meetings.

Cooperative Activities

Considerable time has been spent in cooperating with and encouraging firms and organizations in the development of materials for their own distribution. These materials have been designed to be of assistance to water utilities in their own community relations programs.

Finances

The growth of the financial support for the Advancement Program has been truly phenomenal. In 1958, during the period August 1-December 31, AWWA spent \$10,153; other organizations spent a relatively small, but undetermined, amount. In 1959, AWWA spent approximately \$36,000 plus overhead of its \$45,000 budget appropriation for the period. The Advancement Committee administered

\$20,575 provided by others for the implementation of the Advancement Program, and encouraged and cooperated in parallel programs estimated at a cost of more than \$450,000. Whereas a low five-figure amount was spent on the Advancement Program and parallel programs in 1958, the 1959 total expenditure exceeds \$500,000.

Acknowledgments

The inestimable amount of work and time applied to this program by

AWWA officers, section officers, section advancement committee personnel, and other members should be acknowledged here. Their cooperation has been magnificent and augurs well for the future development of the program. After a little more than a year's work, the Association Advancement Committee and section advancement committees, as well as AWWA members, have tried a lot, have learned a lot about the Advancement Program, and are now in a position to accomplish a lot.

1960 Program

In the committee's 1959 program,¹ it was stated that 1959 would be a year of investigation, appraisal, and trial. Likewise, the 1960 program will have a keynote: to consolidate committee programs based on this past experience in an effort to make more effective those items that met with the best response during 1959.

Management Education

The management education program will continue to encourage the establishment of management education facilities within the sections, under the sponsorship of the section advancement committees. The Association's manual, *Water Utility Management—M5*, is now available and will be promoted for use by committees planning management schools and as the basic text for those attending the management courses. In addition to the use of the manual, consideration will be given to the development of a specific series of courses.

Local Films

The Association, together with the US Junior Chamber of Commerce, will continue to promote the adoption of a joint local project emphasizing commu-

nity information, which, in most instances, is expected to be a "Priceless Water" film. Assistance in planning and producing such a project will be given by the AWWA staff to local utilities involved in the project.

Hometown News

The Association will continue to develop materials for use by section advancement committees in developing hometown news coverage of section meetings. For publicity purposes, photographic coverage of activities at section meetings will continue to be encouraged. The Association plans to withdraw the small financial contribution previously made to establish this coverage. This is being done to make the sections rely on their own initiative and resources.

A major effort will be made to accomplish maximum press coverage, on a hometown news basis, of the 1960 Annual Conference to be held at Bal Harbour, Fla., in May. This coverage will serve as a prototype for news programs of the sections.

Quarterlies and Publications

The quarterly publication, "Advancing Your Water Service," will be con-

tinued. Sections will be encouraged to make arrangements for mailing of the quarterly by municipal leagues or others who can efficiently reach decision makers.

The "Steps Toward Water Utility Advancement," a how-to-do-it series currently appearing in the center section of *Willing Water*, will be continued as a service to members in planning their own community relations activities.

It is also planned to develop, and make available for purchase by utilities, one or more local community relations publications. A very simple, inexpensive brochure with space for local imprinting, entitled "Why Water Is Important," is tentatively planned.

Membership Film

The showing of the membership film, "What's in It for Us?", will continue to be encouraged, particularly to potential members and to decision makers. A brochure promoting AWWA membership will be developed to accompany the showing of the film and for use in general membership promotion activities by the sections.

Trade Press

The trade press program, as presently operating, will be continued, and other publications will be included in the program as they show interest in carrying Advancement material. It is anticipated that, during 1960, some feature material, in addition to AWWA Advancement publicity, can be developed—not only for trade press media, but for general circulation as well.

Personnel Services

In 1960, studies will be made of the urgent manpower needs of the water supply industry with regard to techni-

cal and management personnel. These studies will consider the retention and placement of existing personnel, recruitment of new personnel, and benefits that the Association might make available to encourage both retention and recruitment.

Advancement Award

The Advancement Award for the best local community relations program within each section has been authorized to take effect on Jan. 1, 1960. The award is to be judged by the section advancement committees and presented at the annual meetings of the sections. An information exchange will be developed through Association publications, highlighting the winning community relations projects for the benefit of all the members.

Finances

It is anticipated that in 1960, \$7,500 will be budgeted for the Advancement Program, most of the items that were previously a part of the program now being part of the overall Association budget.

Cooperative Activities

Cooperative activity with other groups and manufacturers will continue to be welcomed and channeled through the Advancement-Liaison Committee. It is felt that the principles and programs of the Advancement effort have been generally accepted by Association members, and that during 1960 a cooperative followup on the development of these projects will highlight the Advancement effort.

Reference

1. COMMITTEE REPORT. Report of the Committee on Water Utility Advancement. *Jour. AWWA*, 51:543 (Apr. 1959).

Report of the Audit of Association Funds

For the Year Ending December 31, 1959

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1959 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually since 1937. They have appeared either in the March or April issue.

Respectfully submitted,
RAYMOND J. FAUST
Secretary

January 21, 1960

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1959, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1959, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & Co.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1959

Assets

<i>Cash in Banks and on Hand</i>		\$ 78,972.14
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Accounts Receivable:

Membership dues.....	\$ 2,044.00	
Advertising—Journal.....	9,351.33	
Reprints.....	499.84	
Sundry standards.....	596.74	
The Story of Water Supply (booklet).....	2,877.48	
Other.....	699.88	16,069.27

<i>Accrued Interest on Bonds</i>		1,267.48
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Inventories:

Paper stock.....	11,893.19	
Type metal.....	3,492.98	
Water Quality and Treatment (book).....	1,838.40	
Manual of Water Works Accounting (book).....	61.09	
Water Rates Manual.....	38.94	
Sundry standards.....	2,890.45	
Quest for Pure Water (book).....	1,165.51	
Survival and Retirement (book).....	678.98	
Willing Water novelties.....	217.90	
Management Manual.....	1,725.50	
Meter Manual.....	426.88	
Cumulative Index—1940—1955.....	1,370.38	
Your Water Supply (booklet).....	411.81	
The Story of Water Supply (booklet).....	3,104.15	
Silent Service Is Not Enough! (manual).....	674.37	
Safety Practice for Water Utilities (manual).....	326.74	
What Price Water? (booklet).....	179.34	
Back issues—Journal—Vol. 1-51, inclusive (41,435 copies).....	—*	30,496.61
Back issues—Proceedings—1881-1913, inclusive (245 copies).....	—	15,659.73
<i>Office Equipment</i> (less depreciation).....		123,039.50
<i>Investments at Cost</i> (Schedule 1).....		6,857.56
<i>Deferred Expenses</i>		925.00
<i>Deposits—Airlines and Postage</i>		

TOTAL ASSETS		\$273,287.29
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Liabilities and Surplus

<i>Accounts Payable</i>	\$ 1,561.68
<i>Membership Dues—Advance Payments</i>	99,068.80
<i>Unearned Subscriptions to Journal</i>	7,598.38
<i>Advance on Publication</i>	5,000.00
<i>Unearned Advertising</i>	2,497.50
<i>Senior Members Contributory Fund</i>	6,010.26
<i>Miscellaneous</i>	121.55
<i>Surplus, per Exhibit C</i>	151,429.12

TOTAL LIABILITIES AND SURPLUS	\$273,287.29
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* Back issues of Journals and Proceedings are inventoried, but no money values are assigned to them for balance sheet purposes, inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

EXHIBIT A, SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1959

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1959
<i>Foreign Securities:</i>				
Province of Ontario.....	4	\$ 1,000.00	\$ 732.50	\$ 966.25*
Government of Canada, 6th Victory Loan.....	3	2,000.00	2,000.00	2,082.50†
Hydro Electric Power Commission of Ontario.....	2.75	5,000.00	5,075.00	4,250.00†
Province of Ontario.....	3	2,000.00	2,022.50	1,785.00†
Hydro Electric Power Commission of Ontario.....	3	2,000.00	2,020.00	1,785.00†
Government of Canada.....	3	5,000.00	4,775.00	4,506.25†
<i>United States Securities:</i>				
US Savings Bonds, Series:				
G.....	2.5	2,500.00	2,500.00	2,432.50‡
G.....	2.5	1,000.00	1,000.00	970.00‡
K.....	2.76	5,000.00	5,000.00	4,845.00‡
K.....	2.76	2,000.00	2,000.00	1,934.00‡
K.....	2.76	25,000.00	25,000.00	24,150.00‡
K.....	2.76	10,000.00	10,000.00	9,660.00‡
K.....	2.76	10,000.00	10,000.00	9,710.00‡
US Treasury Bond.....	4.00	10,000.00	10,000.00	9,410.00
US Treasury Bond.....	4.00	5,000.00	4,925.00	4,705.00
US Treasury Bill.....		5,000.00	4,947.00	5,000.00
US Treasury Notes.....	4.75	8,000.00	8,000.00	7,942.40
<i>Utility Bonds:</i>				
Consumers Power Co.....	4.75	5,000.00	5,431.24	4,875.00
Pacific Gas and Electric Co.....	4.50	5,000.00	5,362.50	4,837.50
American Telephone and Telegraph Co.....	5.00	5,000.00	5,406.25	5,050.00
Commonwealth Edison Co.....	4.25	7,000.00	6,842.40	6,422.50
<i>Totals</i>		\$122,500.00	\$123,039.50	\$117,318.90§

* Payable in United States funds.

† Payable in Canadian funds; market value represents value in New York in United States funds.

‡ These amounts represent redemption value on Dec. 31, 1959.

§ In addition to the above, the Association owns one share of Seymour Water Co. 6 per cent preferred stock, par value \$25, received as a contribution in a prior year. The Association also owns three shares of Wallace & Tiernan, Inc. common stock, \$1.00 par value, \$46 per share market value at Dec. 31, 1959, contributed by the Treasurer of the Association.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1959

Operating Income:

Annual dues.....	\$207,796.15
Advertising—Journal.....	135,639.00
Advertising—Directory.....	12,058.00
Subscriptions to Journal.....	13,789.86
Convention:	
Registration fees.....	49,009.00
Ticket sales.....	5,234.50
Other events.....	289.10
Water and Sewage Works Manufacturers Assn.....	7,500.00
Interest and dividends on investments.....	4,136.80
Miscellaneous income.....	185.35
TOTAL OPERATING INCOME (carried forward).....	\$435,637.76

TOTAL OPERATING INCOME (brought forward)		\$435,637.76
<i>Publication Income:</i>		
Water Quality and Treatment (book)	2,714.48	
One-third of profit from sales of Standard Methods (book)	5,293.04	
Manual of Water Works Accounting (book)	221.55	
Water Rates Manual	512.76	
Sundry standards	15,084.58	
Proceedings and Journals	1,706.71	
Quest for Pure Water (book)	435.25	
Survival and Retirement (book)	328.08	
Willing Water novelties	1,917.14	
Reprints	8,075.20	
Silent Service Is Not Enough! (manual)	263.00	
Public relations material	461.86	
Your Water Supply (booklet)	2,569.92	
The Story of Water Supply (booklet)	12,513.02	
Cumulative Index—1881-1939	18.25	
Cumulative Index—1940-1955	1,204.05	
Safety Practice for Water Utilities (manual)	613.10	
What Price Water? (booklet)	634.95	
Sound slide film	1,720.75	
Management Manual	1,539.60	
Meter Manual	26.00	
Miscellaneous	92.10	
TOTAL PUBLICATION INCOME		57,945.39
TOTAL INCOME (carried forward)		\$493,583.15
<i>Operating Expenses:</i>		
<i>Directors' and Executive Committee Meetings:</i>		
Travel expense		\$ 14,169.77
<i>Administrative Expenses:</i>		
Rent	\$13,500.00	
Office supplies and services	20,743.05	
Membership promotion	336.30	
Pension—Secretary Emeritus	2,500.00	
Contributions to pension system	9,948.36	
Legal and auditing expenses	4,529.68	
General and special travel	2,170.63	
Federal activities	121.93	
Social security taxes	1,690.73	
Hospitalization insurance	690.50	56,231.18
Administrative Salaries		115,225.41
Committee Expense		2,370.03
<i>Division and Section Expenses:</i>		
Section—membership allotment	26,322.36	
Section—travel expense	8,724.60	
Section—general expense	513.89	35,560.85
<i>Journal:</i>		
Printing	73,536.96	
Production	6,973.73	
Paper	25,154.30	
Directory	7,157.46	112,822.45
OPERATING EXPENSES (carried forward)		\$336,379.69

TOTAL INCOME (brought forward).....	\$493,583.15
OPERATING EXPENSES (brought forward).....	\$336,379.69

Convention:

General.....	22,296.29
Entertainment.....	27,546.57
Membership Dues in Other Associations.....	3,639.25
Depreciation of Office Equipment.....	2,895.80
Miscellaneous.....	4,682.65

TOTAL OPERATING EXPENSES.....	\$397,440.25
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Cost of Publications Sold:

Water Quality and Treatment (book).....	\$ 1,026.67	
Standard Methods (book).....	630.09	
Manual of Water Works Accounting (book).....	121.99	
Water Rates Manual.....	161.24	
Sundry standards.....	6,031.32	
Proceedings and Journals.....	10.66	
Quest for Pure Water (book).....	311.49	
Survival and Retirement (book).....	287.93	
Willing Water novelties.....	1,481.91	
Reprints.....	5,546.22	
Silent Service Is Not Enough! (manual).....	117.80	
Public relations material.....	319.65	
Your Water Supply (booklet).....	1,953.60	
The Story of Water Supply (booklet).....	6,964.95	
Cumulative Index—1881-1939.....	66.41	
Cumulative Index—1940-1955.....	995.75	
Safety Practice for Water Utilities (manual).....	271.47	
Special handling and postage charges.....	3,192.81	
What Price Water? (booklet).....	307.96	
Sound slide film.....	1,673.32	
Steel Pipe Manual.....	129.79	
Management Manual.....	1,194.77	
Meter Manual.....	413.78	
Miscellaneous.....	31.54	33,243.12

Development Activities:

Public relations.....	17,000.81	
General publicity.....	35,352.48	
Safety awards.....	432.60	52,785.89

TOTAL EXPENSES.....	483,469.26
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Net Income for the Year (transferred to Exhibit C).....	\$ 10,113.89
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EXHIBIT C—STATEMENT OF SURPLUS FOR THE
YEAR ENDED DECEMBER 31, 1959

Balance, January 1, 1959.....	\$141,315.23
Add: Net income for the year, per Exhibit B.....	10,113.89
Balance, December 31, 1959, per Exhibit A.....	\$151,429.12

American Water Works Association Pension System

BALANCE SHEET—DECEMBER 31, 1959

Assets

Cash in banks	\$ 8,627.78
Accrued bond interest	1,179.58
Investments at cost (Schedule 1)	143,855.20
TOTAL ASSETS	<u>\$153,662.56</u>

Liabilities and Reserve for Future Benefits

Liability for refund of employees' contributions plus earned interest	\$ 17,791.23
Reserve for future benefits	135,871.33
TOTAL LIABILITIES AND RESERVE	<u>\$153,662.56</u>

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1959

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions
<i>Receipts:</i>			
Association contributions	\$11,330.53	\$ 11,330.53	\$ —
Employees' contributions	3,069.58		3,069.58
Interest on bonds	3,896.97	3,896.97	
Interest on savings account	121.69	121.69	
Sale of utility bond	1,000.00		
<i>Total</i>	<i>19,418.77</i>	<i>15,349.19</i>	<i>3,069.58</i>
<i>Disbursements:</i>			
Refund of contributions plus interest	5.63		5.63
Audit expense	50.00	50.00	
Office expenses	20.00	20.00	
Investment in securities	30,860.20		
<i>Total</i>	<i>30,935.83</i>	<i>70.00</i>	<i>5.63</i>
<i>Excess of Cash Receipts Over Disbursements</i>	<i>(11,517.06)*</i>	<i>15,279.19</i>	<i>3,063.95</i>
<i>Adjustments for Non-Cash Items:</i>			
Interest credited to employees' accounts		(433.44)*	433.44
Interest accrued on bonds, Jan. 1, 1959		(829.16)*†	
Interest accrued on bonds, Dec. 31, 1959		1,179.58*‡	
Loss on sale of security		(78.75)*	
		(161.77)*	433.44
Additions to accounts for year	(11,517.06)*	15,117.42	3,497.39
Balance, Jan. 1, 1959	20,144.84	120,753.91	14,293.84
Balance, Dec. 31, 1959	\$ 8,627.78	\$135,871.33	\$17,791.23

* Indicates red figures.

† Accrued interest receivable as per balance sheet Dec. 31, 1958.

‡ Accrued interest receivable as per balance sheet Dec. 31, 1959.

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1959

Description	Interest Rate %	Cost	Quoted Market or Redemption Value, Dec. 31, 1959	Maturity Date
<i>Bonds Registered in Name of Administrative Committee:</i>				
United States Securities:				
US Savings Bonds:				
Series G.....	2.5	\$ 10,000.00		1961
Series G.....	2.5	10,000.00		1962
Series G.....	2.5	14,000.00		1963
Series K.....	2.76	9,000.00	\$ 95,204.00	1964
Series K.....	2.76	17,000.00		1965
Series K.....	2.76	9,000.00		1966
Series K.....	2.76	9,000.00		1967
Series K.....	2.76	20,000.00		1968
US Treasury Note.....	5.00	10,000.00	10,081.25*	1964
US Treasury Bonds.....	4.00	1,970.00	1,886.25*	1969
Utility Bonds:				
Detroit Edison Co.....	3.00	4,565.00	4,275.00*	1970
Brooklyn Union Gas Co.....	2.875	4,089.90	3,862.50*	1976
Consolidated Edison Co.....	2.75	4,200.00	3,562.50	1982
New England Telephone & Telegraph Co.....	3.00	4,030.92	3,775.00*	1982
American Telephone & Telegraph Co.....	5.00	6,480.00	6,026.25	1983
Consumers Power Co.....	4.75	4,315.00	3,950.00	1987
Commonwealth Edison Co.....	4.25	977.50	917.50*	1987
Pacific Gas & Electric Co.....	4.50	5,226.88	4,787.50*	1990
Totals.....		\$143,855.20	\$138,327.75	

* Acquired in 1959.

1959 Section Membership Awards

Old Oaken Bucket		Hill Cup		Henshaw Cup	
Section	Score*	Section	Score†	Section	Score‡
California	1,671	Intermountain	102.990	Cuban	80.4
Southwest	1,060	California	20.680	Pacific Northwest	73.0
New York	904	Iowa	16.296	North Carolina	71.4
Canadian	736	Illinois	11.305	Rocky Mountain	63.2
Illinois	704	Arizona	8.400	Intermountain	57.1
Pennsylvania	554	Alabama-Mississippi	8.040	Arizona	56.1
New Jersey	522	Wisconsin	6.352	Iowa	55.8
Michigan	506	New York	5.104	Montana	55.6
Indiana	501	New England	3.960	Michigan	54.9
Ohio	484	Montana	2.664	Ohio	54.2
Pacific Northwest	460	Pennsylvania	2.296	Wisconsin	49.1
Florida	360	Canadian	2.170	West Virginia	46.3
Southeastern	304	North Central	1.914	North Central	42.0
Chesapeake	299	West Virginia	1.549	Kentucky-Tennessee	38.8
New England	267	Chesapeake	§	Southwest	37.6
North Central	255	Cuban	§	Chesapeake	37.1
Kentucky-Tennessee	251	Florida	§	Illinois	36.5
Alabama-Mississippi	240	Indiana	§	Southeastern	36.3
Missouri	235	Kansas	§	Florida	35.4
Kansas	234	Kentucky-Tennessee	§	Indiana	35.3
Wisconsin	220	Michigan	§	Kansas	35.0
Iowa	207	Missouri	§	New Jersey	32.6
Virginia	206	Nebraska	§	Pennsylvania	21.7
Rocky Mountain	194	New Jersey	§	California	20.3
North Carolina	190	North Carolina	§	Alabama-Mississippi	
West Virginia	114	Ohio	§	Canadian	
Intermountain	110	Pacific Northwest	§	Missouri	
Arizona	104	Rocky Mountain	§	Nebraska	
Nebraska	101	Southeastern	§	New England	
Montana	61	Southwest	§	New York	
Cuban	46	Virginia	§	Virginia	

* Numbers of members.

† Weighted gain in membership.

‡ Percentage of members present at annual meeting.

§ Minus score.

|| Data not available or section not competing.

AWWA Membership Growth

Membership Statement—Year of 1959

	Active	Corporate	Munic. Serv. Subscriber	Associate	Honorary	Life	Junior	Total
Total members, Dec. 31, 1958.....	10,156	966	298	357	45	376	69	12,267
Change of grade, 1959.....	-20	1		-1	4	37	-21	
	10,136	967	298	356	49	413	48	12,267
<i>Gains:</i>								
New in 1959.....	1,083	56	26	13			20	1,198
Reinstated in 1959.....	80	2	3	4				89
	11,334	1,025	327	373	49	413	68	13,554
<i>Losses:</i>								
Deaths and resignations, 1959..	-381	-30	-6	-34	-2	-9	-3	-465
Dropped for nonpayment, 1959..	-705	-35	-16	-19				-775
	10,213	960	305	320	47	404	65	12,314
TOTAL MEMBERS, Dec. 31, 1959..	10,213	960	305	320	47	404	65	12,314
Net gain or loss in 1959.....	57	-6	7	-37	2	28	-4	47

Comparative Statement—Gains and Losses—25-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain	Total Mem- bers at End of Year
1935	565	42	85	190	332	2,682
1936	311	53	104	218	42	2,724
1937	515	86	122	139	340	3,064
1938	520	59	144	140	295	3,359
1939	578	64	122	179	351	3,710
1940	514	58	113	212	247	3,957
1941	480	92	116	236	220	4,177
1942	570	59	132	233	264	4,441
1943	769	88	130	198	529	4,970
1944	734	92	140	171	515	5,485
1945	543	56	111	235	253	5,738
1946	816	79	168	324	403	6,141
1947	933	74	143	349	515	6,656
1948	847	81	207	347	374	7,030
1949	1,083	75	196	323	639	7,669
1950	852	58	128	421	361	8,070
1951	1,090	63	199	441	513	8,583
1952	1,005	66	232	505	334	8,917
1953	1,077	99	263	370	543	9,460
1954	1,160	69	256	493	480	9,940
1955	1,244	90	270	578	486	10,426
1956	1,424	118	284	611	555	11,073
1957	1,425	96	243	699	579	11,652
1958	1,404	111	330	570	615	12,267
1959	1,198	89	465	775	47	12,314



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You guarantee PALATABILITY for pennies per application when you control taste and odor forming substances in your plant with AQUA NUCHAR Activated Carbon.

Every gram of AQUA NUCHAR contains 120 billion particles of activated carbon with 800 square yards of surface area to trap and remove odors. That's why extremely low concentrations (2 - 5 ppm average) are fully effective.

More than 1200 water plants have used AQUA NUCHAR and its universal effectiveness against taste- and odor-forming substances is well recognized.

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MEMO:

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NO SPRINKLING TODAY...

Not everyone's happy as a lark
in the summer*



Every year, in many areas of the country, water wells bottom out, reservoirs bare their skeletons, water pressures drop, and political pressures rise. It's getting worse. In 20 years the country will need twice as much water. New resources will cost billions... *if they can be found at all.* It's time to face up to this problem now.

In your business you can stop costly leaks and careless waste simply by placing meters at key points. They show where you can save water (and money) by improving processes, by recirculating and reconditioning water for re-use.

Water conservation—through accurate metering—is Neptune's biggest business, growing rapidly with the country's need for water. We'll be glad to help you with your water metering problem.

**Our lark's a Hartford robin, in Connecticut's 1957 drought*

NEPTUNE METER COMPANY

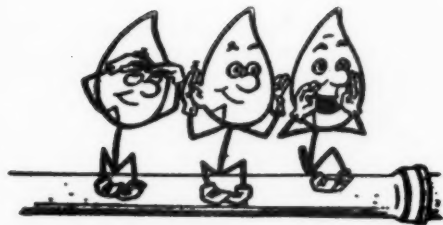
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Percolation and Runoff

Bal Harbour is on the horizon. If you haven't already made a reservation, make it now! If you haven't already made up your mind, make it up now! The technical program will feature sixteen sessions of informed discussion of your most pressing problems. The exhibits will feature almost 200 boothfuls of the newest and best in equipment and materials. The social program will feature a full five evenings of fun in the fabulous Americana Hotel or under the equally fabulous Florida stars. More than 3,000 other AWWA'ers will be on hand to share the information and relaxation. Horizon time is May 15 at 1 PM!

Nematodes—pronounced like Nemesis—are the latest in the series of new "threats" to the public which have been attributed to water supplies. That no real threat has yet been proved evidently matters little; the alarm has been sounded and, loudly, by no less potent voices than those of Drew Pearson, in his column of Feb. 13, and *US News & World Report*, in its Feb. 29 issue. What bothers us even more than the confusion and ill-repute thereby visited upon water workers is the identity of the alarmists and the apparent reason for the alarm. For it

is the USPHS that conjured up the horror of worms in drinking water, certainly not to protect the public, as it offers no solution, but apparently to impress Congress with its need for additional funds for pollution control and research.

Nematodes there are: a large class of microscopic worms that can breed in sewage treatment plants and can in some forms survive chlorination. And nematodes there apparently are in tap waters of many communities served from surface sources. At any rate, USPHS made public the fact that worms were found in the finished water of 14 cities (of 15 studied) drawing supplies from polluted river sources, in 1 (of 4) cities drawing supplies from manmade reservoirs, and in 2 cities drawing supplies from Lake Michigan. They pointed out, of course, that the nematodes themselves are not dangerous to health, but suggested "the possibility that they will ingest pathogens—disease-causing bacteria and viruses . . . that these pathogens are completely protected by the nematodes against chlorination and that they can survive at least 24 hr, with 5 to 15 per cent remaining alive. . . . Thus, they could serve as carriers of disease." They *could*, that is, but just how immi-

(Continued on page 36 P&R)

(Continued from page 35 P&R)

nent the danger to public health is must be judged from the fact that USPHS released the information to the press but didn't even bother to advise the water utilities which had provided the infested samples.

Further information on nematodes, which, we are told, may be present in ground as well as surface supplies, is contained in two JOURNAL articles—one in the May 1959 issue, page 671, the other in the April 1955 issue, page 330. Neither of these should make you, like one of the USPHS scientists, "kind of reluctant" to drink water, but they will introduce you to your worms and suggest a means of determining whether you have them. A more comprehensive article, reporting on the latest research, will appear in an early issue.* Meanwhile, in the hope that it will give you assurance that was lost on the public, we can quote part of the USPHS answer to the question of whether nematodes carry bacteria and viruses that cause such diseases as polio, dysentery, and typhoid fever:

But we must also point out that the chances of these nematodes to feed on pathogenic bacteria and viruses in the sewage treatment plant, under normal conditions, are extremely small. The possibility is there, but it's quite remote.

Looking for the good blown by an ill wind, we can only suggest "attention"—attention that will make your own public interested in your assurances concerning the present system and, perhaps, in your pleas for support of improvements that will make it more inapprehensible not only against the danger of worms, but of synthetic detergents, radioactivity, cancer-causing chemicals, and the various other pol-

lutants mentioned in these articles. As far as the USPHS is concerned, the good is even harder to find. If, as Drew Pearson suggested, the nematodes were called upon to assure additional funds for the water pollution program, they failed, the President's veto of a \$90,000,000 appropriation being upheld by 22 votes in the House of Representatives. And it is rather painfully obvious that the handling of the matter had no beneficial effect upon USPHS's standing among water workmen. As a matter of fact, with nematodes, cranberries, and sundry other subjects, it almost seems as if policy at the Department of Health, Education & Welfare these days must be: HEW to the line, let the chips fall where they may!

An exhibition of equipment and services will be held in conjunction with the Fifth International Water Supply Congress, Berlin, May 29–June 3, 1961. The exhibition will be housed in Congress Hall, where the working sessions will also be scheduled. More than 2,000 representatives of public water utilities are expected to attend the Congress, sponsored by the International Water Supply Assn. Companies interested in exhibition space may obtain details from the secretary general of that organization, 34 Park St., London, W.1, England.

Gerald E. Arnold, general superintendent of the Philadelphia Water Dept., has been named chairman of a special advisory committee working with the Pennsylvania health department on the development of stream temperature standards. Increases in stream temperatures due to industrial activities have become noticeable.

* See also Supplement to March 1960 *Willing Water*.

(Continued on page 38 P&R)

MORE WATER FOR HITCHCOCK'S TRIPLED POPULATION

With a tripling of population in five years, water became a serious problem at Hitchcock, Texas, a suburb of Galveston. Consulting Engineers, Chas. R. Haile Associates, Inc., of Houston and Texas City, recommended a 250,000 gallon double ellipsoidal elevated water tank, among other improvements, which was designed, fabricated, erected, painted and sterilized by Graver. More water and more uniform pressure throughout the system assures a completely satisfied populace.

Calling on Graver skill and craftsmanship is a good way to solve your water problem, too.

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(Continued from page 36 P&R)

A hash mark for Chicago is the new 100,000-gal elevated water tank (see cut) erected by Chicago Bridge & Iron Co. there for a new Libby, McNeill & Libby plant. The tank, which is 130 ft high, stores a fire protection supply for the plant's sprinkler system as well as serving as a high sign for hash—and stew, too, on the other side.




Herbert F. Barrett has been promoted to general sales manager of Buffalo Meter Co. The newly created position will place him in charge of both the industrial division and the water meter division. Howard L. Edwards has been named sales manager in charge of water meter sales. He was formerly vice-president of Sparling Meter Co.

Refreshened—rather than desalted or desalinized or, even, desalinated—water is probably what we ought to be calling what everyone seems to be talking about these days. And, suddenly, though the Dept. of Interior's Office of Saline Water is still going strong with its \$10,000,000 demonstration plant program, it is a new supersecret freezing process, invented by Israeli engineer Alexander Zarchin, and now to be supported jointly by Fairbanks, Morse & Co. and the Israeli government, that is grabbing the headlines. Almost everything about the Zarchin process, except that it is based on freezing, that it is simple, and that it produces fresh water at less than 40 cents per 1,000 gal, is secret. Carrier Corp., which has a contract with the Office of Saline Water for its own freezing process, says wait and see which is the better. Meanwhile, in the textile field, the introduction of a new microporous plastic has been heralded as a boon not only to clothing manufacturers, but to "water-poor areas that may be able to find a cheap, dependable way to purify [refreshen] salt and brackish water through its use."

Even aside from the processers, refreshened water has been receiving greater and greater attention. Down in Curacao, Netherlands Antilles, for instance, the Antillean Brewery, Inc., is producing beer using distilled sea water plus the various ingredients that go into the beer produced by Amstel Brewery of Amsterdam, half-owner of the new company. And in Aruba, where the largest refreshener in the world supplies the population, sensitive instruments produced by Leeds & Northrup Co. are being used to monitor the alkalinity of the water, to feed soda ash into the system as necessary

(Continued on page 40 P&R)



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and Corrosion

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CONCRETE
CYLINDER PIPE**

In the world of dampness and corrosion the most reliable material for permanent water supply and transmission lines is ageless concrete, working together with steel in a properly engineered composite structure. Concrete grows stronger with age, effectively resists soil stresses, and protects steel from electrolytic action and corrosion. American Concrete

Cylinder Pipe is designed to obtain maximum advantage of the strength of steel and the protective characteristics and permanence of concrete. Properly installed, an American Concrete Cylinder Pipeline will retain its high flow capacity indefinitely without maintenance. Investigate the immediate and long-term economies of this superior quality pipe.

American
PIPE AND CONSTRUCTION CO.

American Pipe and Construction Co. • Los Angeles • San Diego
Hayward • Portland • Bogota, Colombia

American Concrete Pipe Co. (subsidiary) • Phoenix • Albuquerque

A MEMBER OF THE AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

(Continued from page 38 P&R)

to maintain a good taste. And in Milwaukee, at a Democratic Party rally, former president Harry S. Truman advanced refreshing as a substitute for birth control in solving the world's population problem, primarily through enabling us to make the deserts bloom.

As a matter of fact, having tried "refreshening," we're not at all sure we don't prefer "desalting."

Thus refresheningly refreshed, Fairbanks, Morse's interest in water reached the poetic point in early January, when it took full-page ads in the nation's leading newspapers to salute water in these terms:

water
comes in oceans, rivers, lakes, wells, drops,
buckets, pitchers, and glasses.
it quenches thirsts, cooks food, puts out
fires,
makes coffee, and brushes teeth.
it spins mills, runs electro-plants,
cools motors, and powers factories.
it spawns fish, sprinkles lawns, floats
boats,
washes children, and grows flowers.
it sustains and nurtures.
it bends if you give it purpose.
it reshapes itself if you give it reason.
it is needed, wanted, feared,
praised, and prayed for.
it is at the heart of all life.
it is in the arteries of all industry.
it is as close to us as skin
but as taken for granted as sky.

the end of water seems unbelievable.
if it is not on the horizon, it is just over it.
if it is not within sight, it is just 'round
the bend.
if it is not in the glass, it is just in the
spigot.

... this is the grand mirage ...
the self-delusion that prevails
though the wells run low

and the streams go dry
and the water slips away.

we know water.
we know its ways.
we've learned its habits.
we've pulled it out of swamplands,
pushed it over mountains,
pumped it into deserts,
tunneled it through granite,
and rescued it from pollution.

above all else,
we know the need for it.
that is why,
for 130 years,
we've developed new uses for,
powered new factories with,
diverted the courses of,
and jealously stood guard over
water.

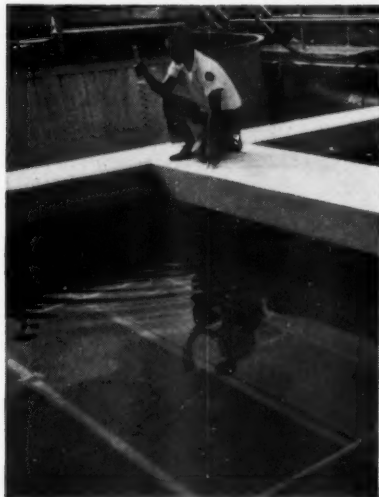
All of which may be advertising, but
to us who work with water how
refreshing!

B-I-F Industries has announced several recent appointments. George W. Kelsey, currently president of WSWMA, has been elected senior vice-president of the firm. He has been a vice-president since 1947. Lyndus E. Harper, president of the Omega Machine Div., has also been elected a vice-president of B-I-F. John R. Hartley was elected president of the Builders-Providence, Inc., Div., and Robert H. Glanville, president of the Proportioneers, Inc., Div.

Thomas H. Collins has been appointed general manager of the Birmingham (Ala.) Water Works Board. Formerly assistant manager, he succeeds E. Clinton Smith, who has resigned to take over the management of the East St. Louis & Interurban Water Co.

(Continued on page 42 P&R)

Florida City Water Plant **SAVES TIME AND MONEY WITH HAGAN COAGULANT AID**



Robert Ankney inspects filter



Coagulant Aid Feeder



Vero Beach, Florida, Water Treatment Plant

Quick case history—reading time 57 seconds

The City of Vero Beach, Florida, has a 6 mgd softening plant that draws water from six shallow wells. The plant formerly used activated silica as an aid to coagulation. While results were satisfactory, the plant investigated other coagulant aids in the hope of increasing the efficiency of their operation. After exhaustive laboratory tests and plant trials, Hagan Coagulant Aid #7 was adopted as it is easy to apply, requires less storage space and only a minimum of supervision. A feed rate of only $\frac{1}{2}$ ppm was set up for the Hagan Aid.

A recent test showed that filters can be operated at 10% above rated capacity for 230 hours with only a 4-foot loss of head; normal filter runs are of 200 hours duration.

Another saving showed up during a

recent expansion, when Gee & Jensen, Consulting Engineers, incorporated feeding equipment specifically designed for Hagan Coagulant Aid #7 into their plans for the new plant. This equipment cost approximately one-fourth as much as equipment that would be needed for activating silica.

Hagan Coagulant Aids are non-toxic, easy to handle, and produce a large, tough floc that speeds settling time and reduces carryover. They may be dry-fed or slurry-fed as desired. Write for Bulletin HSP 919 for information on the complete line of Hagan Coagulant Aids.

HAGAN

CHEMICALS & CONTROLS, INC.

HAGAN CENTER, PITTSBURGH 30, PA.



HAGAN DIVISIONS: CALGON CO.; HALL LABORATORIES; BRUNER CORP.

(Continued from page 40 P&R)

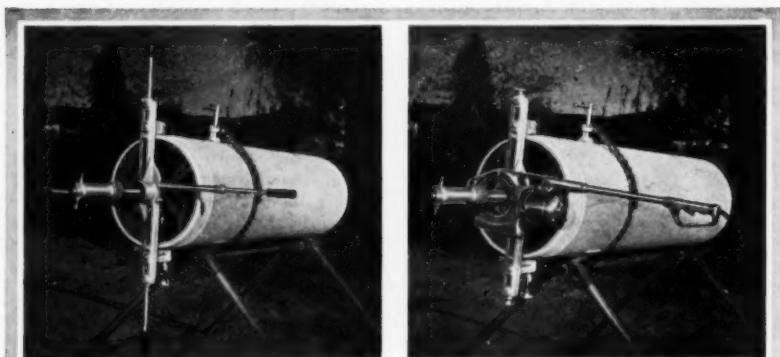
Water filters—that is filters of, rather than for, water—must be just around the corner, now that the tobacco companies have already reached the stage of giving consideration to cheese and charcoal as filter media for the removal of cigaret tars and nicotine. After all, the man who has smoked, or even heard of, a hookah pipe, should be much better prepared to accept the idea of drawing his smoke through water than through a combination of two-thirds Parmesan cheese and one-third charcoal. And just think of the new and lucrative market offered in millions and million of cigarets per day.

It is true, of course, that the water supply industry is rather unlikely to put its research funds into proving, as

did the Wisconsin cheese interests, that its product is capable of absorbing "90 per cent of cigaret tars and nicotine." It is true, too, that water cannot hope to compete with cheese in the almost infinite variety of flavorful fags it can offer. But we rather think that the man whose addiction to tobacco has survived the recent trend toward tastelessness will not be ready for Camembert Camels or Roquefort Raleighs. Psychologically and palatably, the market appears to be ready for Soaking Smoking. It remains only for us to make our pitch.

We've had no trouble with the sales end—"no filter floodback," "the most important quarter gill in smoking today," "the soft-water smoke," etc.—

(Continued on page 44 P&R)



PILOT FIELD LATHES save money by machining asbestos-cement pipe right on the job!

Make factory-like ends on any length when and where you need them. No waiting—no delays.

Power or manually operated. All sizes from 4" thru 20".

Write for details and name of nearest distributor.

Distributor inquiries invited

PILOT MANUFACTURING COMPANY

P.O. BOX 2127, TORRANCE, CALIFORNIA



"But Mayor!
They promised my pump last month!"

"A lot of good that penalty clause is doing us . . . a penalty clause won't pump water . . . and the money the manufacturer loses won't keep our water customers happy. I knew we should have put in an experience clause, too, Mayor. Promises are no better than the outfit that makes them, and we sure got a hold of some amateurs this time. I guess you can't buy both delivery *and* price!"

This integrity . . . this ability is one of the inherent qualities you get when you buy Allis-Chalmers. General Products Division, Allis-Chalmers, Milwaukee 1, Wisconsin.

**ALLIS-CHALMERS
DELIVERS ON TIME**

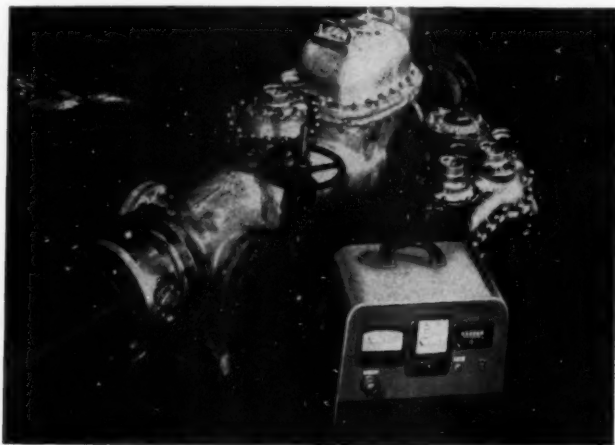
At Allis-Chalmers we have accepted penalty clause contracts because we know that in 99% of the cases we can deliver. That 99% is an actual fact, based on many years of experience in supplying pumps to municipalities. We have the resources and the manufacturing facilities to get pumps delivered when promised.

(Continued from page 42 P&R)

but the production program is holding us back just a little. And suggestions that we can get the best tar and nicotine control by putting our filter at the end to be lighted are no help at all. There must be a way—which is to say, there must not be a whey!

An ultrasonic flowmeter to test large water meters in place, as well as flow in pipelines, has been developed jointly by Hersey-Sparling Meter Co., Dedham, Mass., and Gulton In-

ting device—called a transducer—echoes back and forth inside the pipe. Because of the shift of the beam, only a fraction of it is picked up by a sonic detector in the opposite wall of the pipe. The detector produces a small voltage which can be amplified and read on the voltmeter and which varies with the velocity of flow in the pipeline. The flowmeter is hooked up to remote-control readout devices that show both rate of flow and total flow at any given moment. The ultrasonic devices are



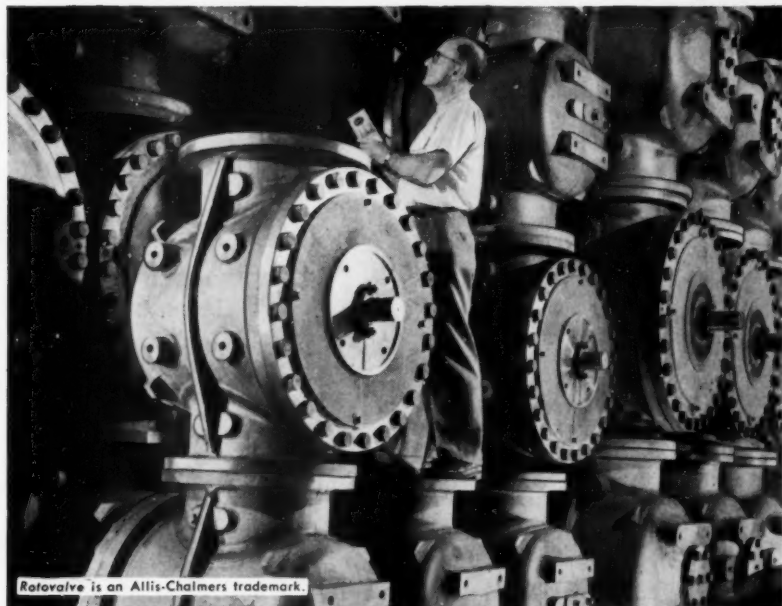
dustries, Inc., Metuchen, N.J. The transmitter and receiver for the sound waves can be attached to the outer walls of a pipe, and nothing need be placed inside it. Unlike other devices of this kind which measure the time required for a sound wave of a given frequency to travel a known distance in the stream of liquid, the Gulton flowmeter sends an ultrasonic beam across the stream and measures the shift of the beam under the influence of the flowing liquid. The sound from the transmit-

ting device is picked up by a sonic detector in the opposite wall of the pipe. The detector produces a small voltage which can be amplified and read on the voltmeter and which varies with the velocity of flow in the pipeline. The flowmeter is hooked up to remote-control readout devices that show both rate of flow and total flow at any given moment. The ultrasonic devices are

A WC, AWOL NBC-TV MC Jack Paar indicated, was the reason for his sudden departure from the air—a WC, described by an American realtor to a British couple as being 9 mi from the cottage he was trying to sell and open only on Thursdays and Sundays. Some cosmopolitan censor at NBC, realizing that WC did *not* mean way-side chapel, found the joke in bad taste

(Continued on page 46 P&R)

ALLIS-CHALMERS



Rotovalve is an Allis-Chalmers trademark.

Standard butterfly and ball valves illustrated are also available from stock in a broad range of sizes.

Another Allis-Chalmers time-saving exclusive: **Cone valves "right off the shelf!"**

Six to thirty-inch *Rotovalve* units — awaiting your call. Think of the valuable time you save! Typical is the case of a western municipality that recently needed one 24-inch and three 20-inch *Rotovalve* units for their waterworks. Allis-Chalmers assembled all accessories required, completed testing and shipped the valves to customer in less than three weeks! Compare this with the 3 to 6 months normally required by other suppliers for delivery.

Perpetual off-the-shelf inventory of *Rotovalve* units, butterfly and ball valves gives Allis-Chalmers today's only complete rotary valve-stocking program . . . guarantees fastest deliveries to you.

Avoid troublesome, costly delays and get the valves you need to do the job right. For immediate assistance anytime, call your nearby A-C valve representative, district office or write **Allis-Chalmers**, Hydraulic Division, York, Pa.

Rotovalve is an Allis-Chalmers trademark.

(Continued from page 44 P&R)

and cut it, precipitating the highly publicized dePaarture. What concerns us, of course, is the water involved and the publicity lost. Just imagine traveling 18 mi in the middle of the night to get Junior a d'ink!



James C. Harding, commissioner of the Westchester County Department of Public Works, White Plains, N.Y., was recently appointed by Governor Rockefeller to the state's Water Resources Planning Commission.

A member of the Association since 1922, he is a Life Member. He received the Diven Medal in 1945 and the Fuller Award in 1959, and served as Director from the New York Section in 1953-56.

A new Water Resources Center, scheduled for completion in May 1960, will about triple space available on the Ohio State campus for chemical and biologic research in water, sewage, and industrial wastes. The \$180,000 facility has been made possible by a grant from the National Institutes of Health and a state appropriation.

Harvey O. Banks, director of the California Water Resources Dept., has been named chairman of the Interstate Conference on Water Problems, a continuing organization of state officials concerned with water resources.

Elected vice-chairmen were Robert L. Smith, Kansas Water Resources Board, and Sam Thompson, Mississippi Board of Water Commissioners; William C. Ackermann, Illinois Water Survey, is secretary-treasurer.

Henry Pratt Co. has appointed Henry C. Schwenk as vice-president in charge of sales. He formerly was general sales manager.

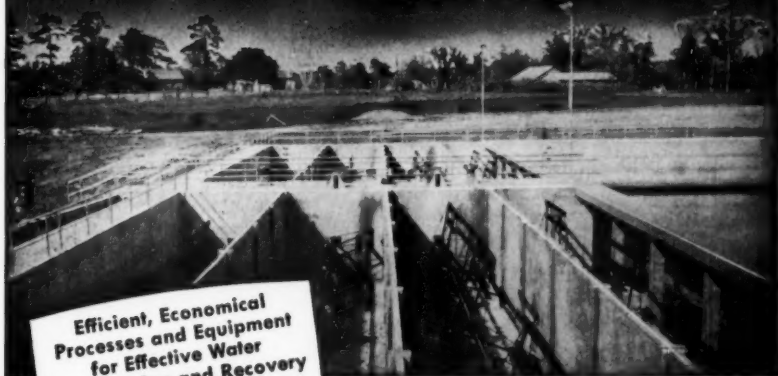


More than one million Americans are living proof. Remember . . . your contributions helped save many of these lives. Your continuing contributions are needed to help discover new cures and, ultimately, the prevention of cancer itself • Remember, too, if you delay seeing your physician, you drastically cut your chances of cure. Annual checkups are the best way of detecting cancer in time • Guard your family! Fight cancer with a checkup and a check.

AMERICAN CANCER SOCIETY

(Continued on page 48 P&R)

IMPROVE Water Treatment with PROVED American EQUIPMENT



Efficient, Economical
Processes and Equipment
for Effective Water
Conditioning and Recovery

CONTINUOUS PIPELINE CHEMICAL MIXING

THE HOMOMIX—provides instant, violent, uniform, and complete mixing of one or more chemicals or gases with water—continuously or intermittently, *without the use of a mixing tank!* Designed with one or more stages of direct-connected motor driven diffuser impellers rotating in blending chambers, it forms part of the influent piping. Discharges directly across the flow-through stream. Mixes instantaneously at the point of entry. Lift impeller can be added to provide additional head, if required. Send for Technical Supplement HM and Bulletin 300.

IRON AND CARBON DIOXIDE REMOVAL

THE FERROFILTER—removes iron, manganese, carbon dioxide, and other dissolved gases and odors—efficiently and economically, in one simple operation. Utilizes fine media in open aeration. Write for Bulletin No. 252B.

SOFTENING AND TURBIDITY REMOVAL

THE FLOCSETTLER—combines in one unit all modern concepts of water and waste treatment, including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. Send for Technical Supplement FL.

RAPID MIX AND FLOCCULATION UNITS

PADDLE-PROPELLER-RM TYPE MIXERS—for rapid mixing to obtain continuous blending of chemical with raw water.

PADDLE-DOWNFLO FLOCCULATION UNITS—designed to efficiently carry out the slow mixing and flocculation functions required in the coagulation process. Choice of vertical and horizontal units. Send for Technical Supplement PF.

SLUDGE REMOVAL

POSITIVE FLIGHT CONVEYORS—for rectangular settling tanks. Heavy-duty solid shafting, bab-bitted plate sprockets. Heavy adjustable self-aligning wall bearings, furnished with foundation bolts welded to templates and eccentric washers for economical installation.

CIRCULAR CLARIFIERS—Structural steel bridge, steel flights in staggered position mounted on two radial trussed arms driven by motorized gear reduction unit. Write for Bulletin 253B.

PUMPS

Complete line of double-suction split-case single-stage, two-stage, end suction, axial flow, sludge, and deep well turbine pumps—for wide range of raw water, low lift, high lift, backwash, and general service pumping requirements. Send for Bulletins 248A, 246A, 251A, 245A.

Utilize our experience in engineering design and manufacture of field-proved equipment and pumps for water and waste treatment

AMERICAN WELL WORKS

IN OUR 52ND YEAR
112 North Broadway
AURORA, ILLINOIS



Pumping, Sewage Treatment, and
Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

Offices: Chicago • New York • Cleveland • Cincinnati • Kansas City • Sales Representatives throughout the World

(Continued from page 46 P&R)

AWWA's reserve stock of the October 1959 issue of the JOURNAL (Vol. 51, No. 10) has reached—in fact, passed—the vanishing point, with the result that we are unable to fill outstanding back orders for it. If you no longer need your copy, and it is in good condition, we would be glad to pay 50 cents for it. Send it to:

AWWA Back Order Dept.
2 Park Avenue
New York 16, N.Y.

Mark the envelope "Second Class," so that only 13 cents' postage will be required.

Some members and subscribers who were added to the mailing list after October 1959 but who are entitled to a copy of that issue may not have re-

ceived it. In that case, if you request it, your name will be placed on a list to be sent a copy when it becomes available.

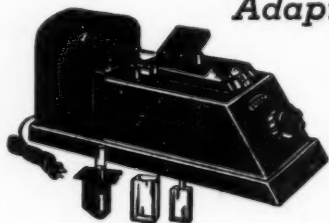
The shortage, incidentally, is not due to an unusual demand for the issue but to the fact that a large number of reserve copies were used in a special membership promotion, without adequate provision for inventory. We deeply regret any inconvenience caused by this miscalculation.

Dorr-Oliver Inc. announces the appointment of J. D. Hitch Jr., former president, as chairman of the board. He was succeeded as president by L. R. Boling, formerly executive vice-president.

(Continued on page 50 P&R)

KLETT SUMMERSON ELECTRIC PHOTOMETER

*Adaptable for Use in Water
Analysis*



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.

What type of large-diameter water pipe

...carries the highest internal pressures?

...withstands the most severe shock loadings?

...gives the tightest, most leak-free joints?

...has the greatest beam strength to span washouts?

...gives proof of quality?

(every length tested in the shop to AWWA standards)

Only large-diameter steel pipe is the answer to every one of these questions.

Bethlehem large-diameter steel pipe (from 18 in. ID to the largest size you may need) is coal-tar enameled in the shop for long-lasting high-flow capacity and resistance to corrosion. And every length is tested to AWWA standards, usually to twice the design pressure.

What better investment could you make in your community's water supply program than to use tried-and-proven Bethlehem steel pipe?

The nearest Bethlehem sales office will gladly give you full details.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Export Distributor:
Bethlehem Steel Export
Corporation



BETHLEHEM STEEL

(Continued from page 48 P&R)



As a matter of fact _____

A quarterbuck seems in the offing soon, for, though the decline has slowed a bit in late years, the value of the 1900 dollar still continues to dip. In 1959, according to the National Bureau of Economic Research and Bureau of Labor Statistics, it reached a low of 28.84 cents, having dropped from 67 cents in 1933 to 48 in 1945 and 35 in 1950.

Into 'hot' water is where Edwin Roedder of the USGS has us heading, estimating that by the year 2000 the nation will have to dispose of 16,000,000 tons of atomic byproducts. This total will include 10-30 tons of strontium-90, 1 g of which, evenly distributed in the world's drinking water supplies, would make them unsafe.

Bad breaks do not a crisis make was the point made by Armand D'Angelo, commissioner of New York City's Dept. of Water Supply, Gas & Electricity, in facing the press after a week-end epidemic of ruptures last summer. Presenting the facts, he noted 401 breaks for New York in 1958; 637 for Philadelphia in 1957; 743 for Detroit in July 1956-June 1957; 144 for Chicago in 1957; and 165 for Denver in 1957.

Babies, those things of which water customers are made and whose pre-

vention, or at least control, has become a worldwide political and moral and religious issue, are apparently not going to let the worry of nonbabies discourage them. At any rate, market data predictions indicate an increase of the US kiddie crop from 4,000,000 per year now to 6,000,000 per year in 1970.

Engineering graduates in 1959 reached a new high not only in numbers (38,162) but in emolument (a term reserved for big dough), according to a survey by EJC's Engineering Manpower Commission. Median starting salary for new graduates in all industries was \$510 per month, ranging from \$461 in consulting work to \$526 in aircraft. Median for M.S. degree graduates was \$600 per month and for Ph.D. graduates \$825.

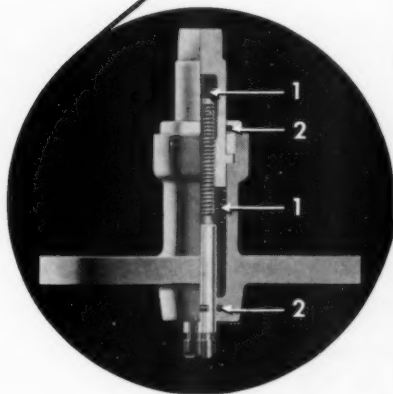
A fluoridation slowdown was reported by Arthur S. Flemming, Secretary of Health, Education & Welfare, in a pre-Christmas interview in which he stated that only 97 communities had adopted the procedure in 1959, compared with 233 in 1956. He noted also that the number of people denied fluoridation had increased from 73,500,000 to 76,800,000. During the year 24 communities rejected fluoridation in referendums and 3 voted to discontinue existing programs.

(Continued on page 102 P&R)

WHAT'S INSIDE?

A BIG PLUS

AUTOMATIC LUBRICATION AND DOUBLE "O" RING SEALS



Smith Fire Hydrants are easy to operate, inexpensive to maintain and most dependable in meeting severe climate and operating conditions. In addition to maximum flow and simplicity of design, Smith Hydrants now have two additional features of major importance: (1) Automatic lubrication — chamber sealed with "O" Rings contains a permanent type lubricant — temperature range -30° to 200° F. Each time the hydrant is operated, the threads and bearing surfaces are automatically lubricated. (2) "O" Ring Seals — the lower "O" Ring seals the internal pressure, the upper "O" Ring is a combined external dirt and moisture seal. This construction eliminates the conventional stuffing box and packing gland adjustments.

65



THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

*"They wuz a little slow
beginnin'...but look at 'em
lay Tyton now!"*



U.S.
cast iron
PIPE

FOR WATER, SEWERAGE AND

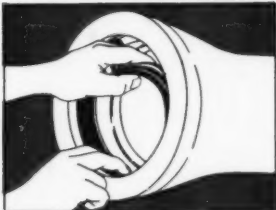
everybody's doin' it

Laying Tyton Joint® pipe, that is. This easy-to-assemble pipe is so foolproof even a bear can get in the act. Only one accessory needed—a simple rubber gasket. No bell holes. No caulking equipment. No nuts or bolts to fiddle with. No weather worries, either. Tyton doesn't mind wet feet . . . can be laid in rain or wet trench.

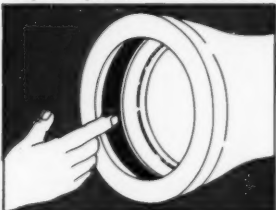
Result: more working days, more lengths laid per man hour, lower installation cost. Sound interesting? It is! Call or write for the facts.

TYTON®

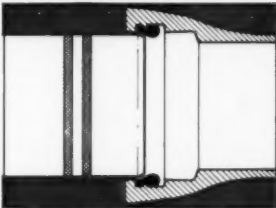
ONLY FOUR SIMPLE ACTIONS



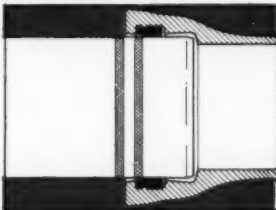
Insert gasket with groove over bead in gasket seat . . . a simple hand operation.



Wipe film of Tyton Joint® lubricant over inside of gasket. Your receiving pipe is ready.



Insert plain end of entering pipe until it touches gasket. Note two painted stripes on end.



Push entering pipe until the first painted stripe disappears and the second stripe is approximately flush with bell face. The joint is sealed . . . bottle-tight, permanently! The job's done . . . fast, efficiently, economically. Could anything be simpler?

U.S. PIPE AND FOUNDRY COMPANY
General Office: Birmingham 2, Alabama

A Wholly Integrated Producer from Mines
and Blast Furnaces to Finished Pipe.

INDUSTRIAL SERVICE

CASE & ENGIN



The Reading Meter

Handbook of Chemistry and Physics. Charles D. Hodgman, ed. Chemical Rubber Publishing Co., 2310 Superior Ave., Cleveland 14, Ohio (41st ed., 1959) 3,350 pp.; \$12

The newly available 41st edition of this handbook matches the excellent standards set by its predecessors. Although no handbook could ever be said to "have everything," this is one of the three or four that deserve a place in every technical reference library. The data contained cover mathematics, properties and physical constants of inorganic and organic compounds, specific gravity and properties of matter, heat and hygrometry, sound, electricity and magnetism, light, and units of measurement. By using India paper for its well over 3,000 pages, the thickness of the volume has been kept to 3 in. (it is 7½ in. high and 5 in. wide), so that it remains a true "hand" book.

Writing and Publishing Your Technical Book. F. W. Dodge Corp., 119 W. 40th St., New York 18, N.Y. (1959) 50 pp.; paperbound; free to prospective authors

If you contemplate writing a business, professional, or engineering book, you will find it well worth while to obtain this informative booklet. Prepared by the Dodge Books staff, it is intended to help authors organize and develop their ideas for books to the point where a publisher's interest may be aroused. The booklet an-

swers many questions about the author-publisher relationship (including a point-by-point discussion of the standard publishing contract), and also presents a number of checklists of considerable practical value to an author in getting material ready for publication.

OTHER PUBLICATIONS RECEIVED

Safety in Wastewater Works. Manual of Practice No. 1, Water Pollution Control Federation, 4435 Wisconsin Ave., Washington 16, D.C. (1959) 64 pp.; paperbound; \$1.50

Revision of an earlier manual on "Occupation Hazards"; includes material on accident prevention, rescue practices, safety recommendations, and report forms.

American Standard: Safety in Welding and Cutting—Z49.1-1958. American Welding Society, 33 W. 39th St., New York 18, N.Y. (1958) 49 pp.; paperbound; \$2

Revision of 1950 standard; covers equipment installation and operation, fire prevention, and personnel protection.

The Law of Water Allocation in the Eastern United States. David Haber & Stephen W. Bergen, ed. Ronald Press Co., 15 E. 26th St., New York 10, N.Y. (1958) 643 pp.; paperbound; \$7.50

Papers and proceedings of symposium sponsored by Conservation Foundation, held in Washington, D.C., October 1956; water rights law and use problems con-

(Continued on page 56 P&R)

FLUIDICS* AT WORK

Flow Level Pressure Valve Control Pump Control



Unattended Pumping Station

Cut costs, improve efficiency—
automate your present water system
with Simplex Orthoplex
Supervisory Control

ORTHOPEX SYSTEM can pay for itself during the first year of operation.

ORTHOPEX assumes the responsibility for automatically controlling remote pumping stations, control valves, elevated tanks, reservoirs — **FREES PERSONNEL FOR MORE IMPORTANT JOBS.**

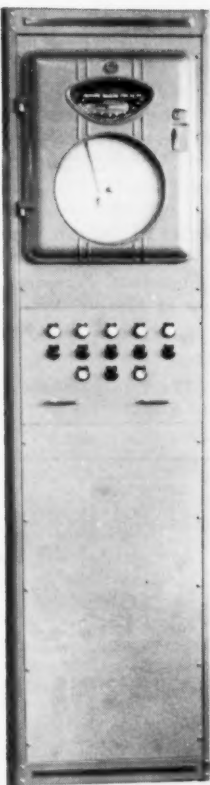
ORTHOPEX can be installed to operate with most existing flow- and level-sensing devices without change or with the addition of new low-cost devices.

IMPROVED DESIGN reduces maintenance to the minimum by the elimination of all vacuum tubes, motorized timers and motorized sequence switches.

AS MANY AS 29 CHANNELS over a single pair of wires—private or telephone.

FOR COMPLETE INFORMATION, send us your requirements.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.



Central Control Station

SIMPLEX

VALVE AND METER COMPANY

a division of PFAUDLER PERMUTIT INC.
Lancaster, Pennsylvania

Specialists in FLUIDICS...the science of fluid processes

SEE THE SIMPLEX ORTHOPEX IN ACTION AT OUR BOOTH AT THE A. W. W. A. NATIONAL CONVENTION AT BAL HARBOUR, FLORIDA, MAY 15—20, 1960

The Reading Meter

(Continued from page 54 P&R)

sidered from legal, economic, engineering, hydrologic, and administrative viewpoints.

Illinois Water Rights Law and What Should Be Done About It. John E. Cribbet. *Illinois Chamber of Commerce, 20 N. Wacker Dr., Chicago 6, Ill. (1958)* 73 pp.; paperbound; \$1

Review of water rights law and allocation practice, with recommendations approved by Water Resources Committee of State Chamber of Commerce.

Atlas of Illinois Resources. Section I—Water Resources and Climate. Div. of Industrial Planning & Development, State of Illinois, Springfield, Ill. (1958) 58 pp.; paperbound; price not stated

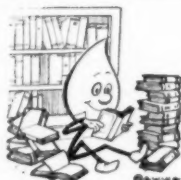
Data on geology, hydrology, water quality, precipitation, and temperature; maps and charts.

Appraisal and Valuation Manual, 1959. *American Society of Appraisers, Manual Div., 369 Lexington Ave., New York 17, N.Y. (1959)* 525 pp.; \$15

Fourth volume in series; contains 40 articles on various aspects of appraising, including evaluation of water wells and riparian rights, maintenance of property records, and rate case preparation.

Water Fluoridation Practices in Major Cities of the United States. William T. Ingram, ed. *College of Engineering, New York University, University Heights, New York 53, N.Y. (1959)*; paperbound; price not stated

In two parts—Part I is basic report, Part II consists of detailed data for individual cities; condensed version of report appeared in September 1959 *JOURNAL AWWA* (p. 1095).



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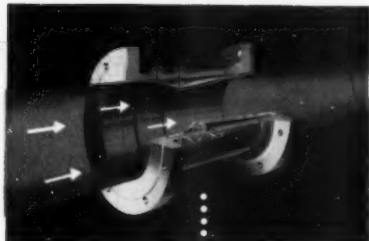
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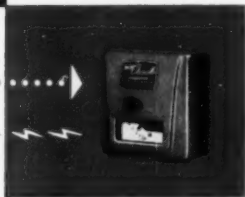
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CHEMICAL ANALYSIS

Determination of Monobromamine and Monochloramine in Water. J. K. JOHANNESSON. *Analyst*, 83:155 ('58). When water, such as sea water in swimming pools, which contains both ammonia and bromide, is disinfected with chlorine, both monochloramine and monobromamine are formed. Solns. of monobromamine were shown to be much more strongly bactericidal than monochloramine solns. of the same equiv. oxidizing strength. Bactericidal effects are also affected by reaction of monobromamine with secondary amines diffusing from the bact. cells; monochloramine does not react in this manner. Curves are given showing death rate of *Esch. coli* exposed to monochloramine and monobromamine, each in concns. equiv. to 0.15 ppm chlorine, under identical conditions. The study and control of the chlorination of water under conditions favoring the formation of monobromamine and monochloramine therefore requires a method of analysis capable of differentiating between these 2 compds. A survey of possible methods is reported. Of the methods tested, the methyl orange method does not distinguish between the 2 compds.; and the FAS method using *o*-tolidine does not differentiate between free bromine, combined bromine, and free chlorine. An amperometric method using a rotating platinum electrode was therefore proposed and investigated. A test is first made to det. whether bromine or chlorine is present in free or combined forms. If free chlorine or bromine is present, addn. of an ammonium salt causes a large rapid decrease in the diffusion current. Monobromamine or free bromine is then detd. by titration with phenyl arsenoxide soln. at zero applied voltage. Monochloramine or free chlorine is detd. by adding potassium iodide soln. and titrating again with phenyl arsenoxide. Results obtained by the FAS and amperometric methods are tabulated; and the amts. of monobromamine and monochloramine formed

on chlorinating sea water contg. excess ammonia are shown graphically.—*WPA*

Spectrophotometric Determination of Fluorine With Particular Reference to Water. B. VISINTIN & S. MONTERIOLO. *R. C. Ist. sup. Sanit.*, 21:338 ('58) (English summary). After a detailed review of colorimetric and spectrophotometric procedures for the determination of low concentrations of fluorine, experiments are reported on the application of 3 of the methods to the determination of fluorine in water. The pertitanic acid method was not sufficiently sensitive and the results were not reproducible. A spectrophotometric technique developed using the zirconium-alizarin reagent was found to be the most suitable method for use in the analysis of drinking water. Fluoride ions in concns. up to 1.50 mg/l could be determined by direct reading at 530 m μ with an accuracy of 0.03 mg/l and concentrations between 1.5 and 2.0 mg/l with an accuracy of 0.05 mg/l. The most suitable reagent was obtained with concns. of $8 \times 10^{-4}M$ alizarin and $4 \times 10^{-4}M$ zirconium in 1.35N sulfuric acid. Factors affecting the sensitivity and stability of reagent and chromatic reaction were also investigated, especially with a view to correcting the photometric readings. The aluminium eriochrome cyanine method was found to be the most suitable procedure for the analysis of water contg. high concns. of minerals. The fluoride ion can be detd. in concns. of 2-8 mg/l with a reproducibility of ± 0.05 mg/l, providing the temp. and the duration of the reading do not differ by more than $\pm 1^\circ C$ and 5 min, respectively, from the values used in the construction of the calibration curve.—*WPA*

Determination of Deuterium Oxide in Water by Measurement of Freezing Point. P. B. REASER & G. E. BURCH. *Science*, 128:415 ('58). A simple rapid method has been devised for the detn. of deuterium oxide in water, by measurement of the

(Continued on page 68 P&R)

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(Continued from page 66 P&R)

freezing point. The apparatus used is the Fiske osmometer, which is based on the principle that slightly supercooled solns. can be rapidly frozen by agitation and that the temp. of the ice crystals can be measured during the few seconds it remains constant; this temp. is considered to be the freezing point.—WPA

Determination of Small Quantities of Polyglycolic Surface-Active Agents in Water. H. ETIENNE. *Bul. Centre Belge Et. Document. Eaux* (Liege), 40:159 ('58). In a paper presented at a meeting in Liege, 1958, the author described the development of a selective method for the determination of polyglycolic ethers in water in min. concns. of about 0.2 ppm. The method is based on ppn. of the phosphomolybdic complex, with precautions to insure elimination of interfering compds., principally other surface-active agents and nitrogen compds.; and involves: concn. of the water sample by boiling, ppn. of the complex by addn. of calcium chloride and phosphomolybdic acid in the presence of a coagulant (Celite), centrifuging, washing the ppt. first with water and then with petroleum ether, treatment with hydriodic acid to form ethyl iodide, removal of ethyl iodide in a stream of carbon dioxide, and oxidation with bromine to form iodic acid which is determined iodometrically. Full exptl. details and descriptions of the apparatus are given, and the results are tabulated for several river waters and water supplies to which known amts. of polyglycolic ethers had been added. The precision of the method was satisfactory. It is particularly applicable to the surface-active polyglycols most often found in water, namely the simple and hydrophilic ethers. For lipophilic ethers the washing with petroleum ether should be omitted; and for esters the method is limited owing to the possibility of hydrolysis.—WPA

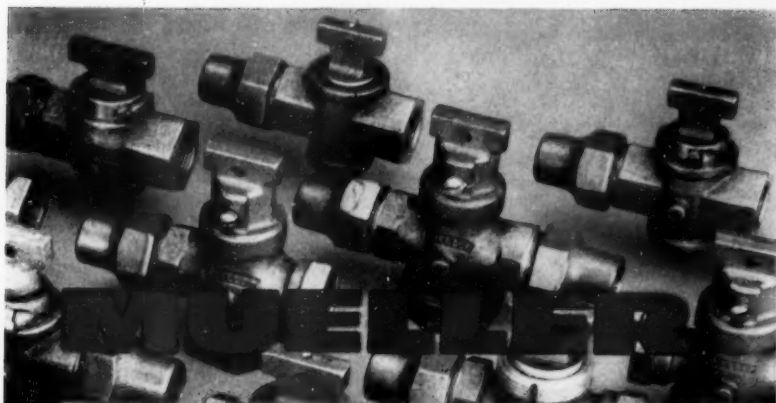
Portable Analyzer for Determination of Dissolved Oxygen in Water. Application of Rapid-Dropping Mercury Electrode. C. P. TYLER & J. H. KARCHMER. *Anal. Chem.*, 31:499 ('59). A portable polarographic apparatus has been developed for the determination of dissolved oxygen in water and waste waters. It uses a mercury drop time of about 0.25 sec per drop, which pro-

duces a current relatively insensitive to agitation or to sample flow. The low drop time is achieved by mounting the dropping mercury electrode horizontally in the electrolytic cell and by judicious selection of the parameters of the capillary. The method is applicable to samples with pH values of 4.5-11.0 and with salt concns. between 0.001 and 0.05M. Detailed procedure is given for constructing the apparatus and carrying out the determination.—WPA

Polarographic Determination of Dissolved Oxygen—Study of Drop Time With Rapid-Dropping Mercury Electrode. J. H. KARCHMER. *Anal. Chem.*, 31:502 ('59). A single capillary was used to study the effect of very small drop times at a constant mercury flow rate on the polarographic current produced by dissolved oxygen in water. The capillary was mounted first vertically, then horizontally, and finally its orifice was scratched and it was mounted vertically. Currents produced with very low drop times were considerably less than those predicted from the Ilković equation. When the solutions are stirred the effect on the current is less as the drop time decreases and the mercury flow rate becomes greater. The fundamental equations governing the drop times and mercury flow rate were studied and reduced to simple forms so that predictions involving mercury pressure, capillary length, capillary radius, and interfacial tension could be made in selecting capillaries of desired characteristics.—WPA

Polarographic Determination of Oxygen—Anomalous Current Encountered With Rapid-Dropping Mercury Electrode. J. H. KARCHMER. *Anal. Chem.*, 31:509 ('59). In using a rapid-dropping mercury electrode at about 0.25 sec per drop for the polarographic determination of dissolved oxygen in water (see preceding abstracts), it was found that abnormally high currents were obtained as the salt concn. of the sample increased above 0.05N. This anomaly was found to be related to the water current. This effect, which is seldom obtained with conventional drop times of 3-6 sec per drop, is accentuated as the drop time decreases and the total current increases; however, the addition of massive quantities of gelatine completely eliminates this type of current without seriously repressing the true diffusion current.—WPA

(Continued on page 70 P&R)



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(Continued from page 68 P&R)

New Tonometric Method for the Determination of Dissolved Oxygen and Carbon Dioxide in Small Samples. J. D. JONES. *J. Exp. Biol.*, 36:177 ('59). A microtonometric method is described for the determination of carbon dioxide, oxygen and nitrogen in fluid samples with a volume of 0.3 ml or less. The method involves equilibrating a relatively small gas bubble with the sample and subsequently analyzing the bubble. Each determination takes 20-25 min. Detailed procedure is described, and an illustrated description of the apparatus is given. The results obtained are in close agreement with those obtained by a micro-Winkler method.—WPA

Microdetermination of Dissolved Oxygen by Hypodermic Syringe. P. HOLLAND. *Chem. & Ind.*, 218 ('59). Equipment and procedure are described for sampling boiler feed water with a 1-ml syringe, and determining the dissolved oxygen content by an absorptiometric method using the orthotolidine reagent. Precautions are taken to avoid the introduction of air bubbles. The method was developed for measuring oxygen concentrations below 0.01 ppm and the results are reproducible to at least 0.003 ppm; for concns. greater than 0.02 ppm a correction must be applied.—WPA

Determination of Ammonia in Water. L. KRIEGER. *Ann. Pharm. Franc.* (Fr.), 15:731 ('59). A method for the determination of ammonia in water is described. The water is placed in the larger vessel of a Fleury "micro-Schloesing" apparatus, and 1 ml of 0.01N sulfuric acid is placed in the smaller vessel, which is supported inside it by a glass tripod. The apparatus is closed, and heated at 37°C for 30 min. After 1 ml of alkali has been added to the water, the apparatus is closed, and heated again at 37°C for 24 hr. The contents of the small vessel are then treated with Nessler's reagent, and the absorption is measured by an electrophotometer.—WPA

Fluorometric and Colorimetric Estimation of Cyanide and Sulfide by Demasking Reactions of Palladium Chelates. J. S. HANKER; A. GELBERG; & B. WITTEN. *Anal. Chem.*, 30:93 ('58). Rapid, sensitive, fluorometric and colorimetric methods are described for the determination of microgram quantities of sulfide and cyanide. Both the

methods are based on demasking reactions of palladium chelates. The fluorometric method depends on the demasking of 8-hydroxy-5-quinolinesulfonic acid, by cyanide or sulfide, from the nonfluorescent potassium bis(5-sulfoxino) palladium. The liberated 8-hydroxy-5-quinolinesulfonic acid then coordinates with magnesium ion present to form a fluorescent chelate which is a measure of the amt. of cyanide or sulfide present. By this method, 0.02 µg of cyanide or 0.2 µg of sulfide per ml of soln. may be detd. The colorimetric method depends on the demasking of 8-hydroxy-7-iodo-5-quinolinesulfonic acid from the yellow potassium bis(7-iodo-5-sulfoxino) palladium. The demasked 8-hydroxy-7-iodo-5-quinolinesulfonic acid then coordinates with ferric ion present to form a blue-green chelate which is a measure of the amt. of cyanide or sulfide present. This method is less sensitive than the fluorometric method; concns. of 1 µg of cyanide or sulfide per ml may be determined. Thiols, thio-cyanates and certain disulfides also give this reaction.—WPA

Colorimetric Determination of Phosphoric Acid in Boiler and Boiler Feedwater. W. KUHN & J. BOCHEM. *Mitt. Ver. Grosskesselbesitzer* (Ger.), 60:238 ('59). Usual colorimetric method for detg. H_3PO_4 with acid V-Mo soln. is modified in such a way that P_2O_5 , in the range from 3 to 50 mg/l, can be detd. with sufficient accuracy within 5 min by simple colorimetric comparison. Interference by SiO_2 is avoided. When a photometer is used, the method is practicable down to 0.1 mg P_2O_5 and can be used for boiler feedwater research. Prepare the V-Mo reagent as follows: Dil. 145 ml of 96% H_2SO_4 to 400 ml. Dissolve 1 g of $(NH_4)_2VO_4$ and 25 g of $(NH_4)_2MoO_4$ in 500 ml of boiled hot H_2O . Cool the soln. to 10-15°, and add the dild. H_2SO_4 with stirring. Make the soln. up to 1,000 ml with previously boiled distd. H_2O . The detn. is carried out as follows: Place 10 ml of clear filtered boiler water in a test tube calibrated at 10 and 12 ml. Add 2 ml of the V-Mo reagent. After 5 min compare the color with that of a standard soln. or in a photometer. In the latter, the extinction owing to the V-Mo reagent must be subtracted from that found in the test. Tests indicated that little interference is given by SiO_2 concns. up to 1,000 mg/l.—CA

(Continued on page 72 P&R)



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(Continued from page 70 P&R)

Determination of the Isotope Composition of Some Natural Sources of Water. L. M. YAKIMENKO, ET AL. *Zhur. Priklad. Khim.* (USSR), 32:1244 ('59). The isotopic compn. of H_2O from the Moscow supply sampled May '52 and from a mountain river in Caucasus taken Mar. '52 were detd. by normalization at $400 \pm 10^\circ$ with H^1 obtained in a single-step electrolysis. Normalization was made in a continuous-working 13-step isotopic exchange assembly, each step of which consisted of an evaporator, a holder of the O-free Ni catalyst, and a condenser cooled to $9-10^\circ$. The d. was detd. by the float method. The D content of Moscow H_2O was $15.8 \pm 0.2 \text{ } \gamma/\text{cc}$ and that of mountain river H_2O $15.0 \pm 0.2 \text{ } \gamma/\text{cc}$. The O isotope compn. of both waters did not differ by more than $0.2 \text{ } \gamma/\text{cc}$.—CA

Determination of the Isotope Composition of Water From the Moscow Water System. L. M. YAKIMENKO, ET AL. *Zhur. Priklad. Khim.*, 32:1251 ('59). Isotope analysis of Moscow H_2O was made by slow (25-48 days) electrolysis with a const. vol. of electrolyte and no samples removed so that equil. was established between the feed and the gases enriched with heavy isotopes of H and O. The D content was $15.5 \text{ } \gamma/\text{cc}$ and the correction for the excess content of heavy O in the air compared with that in the H_2O was $8.0 \text{ } \gamma/\text{cc}$.—CA

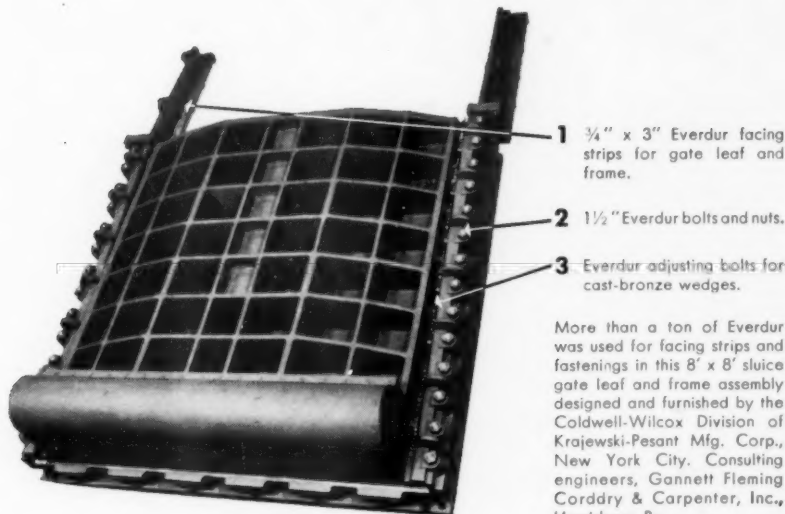
The Method Used by P. M. Butirina for Chemical Analysis of Underground Water. V. M. DUBLYANS'KII. *Pratsi Odes'k. Derzhav. Univ. im. I.I. Mechnikova, Prirod-nichi Nauki* (USSR), 148:3:323 ('58). By using this method the following detns. were made: detn. of HCO_3^- ions by titration with $0.05N$ HCl in presence of methyl orange; detn. of Cl^- by argentometric method and the use of $CaCrO_4$ as indicator; detn. of SO_4^{2-} by turbidimetric method of P. M. Butirina (reagent is $Ba(NO_3)_2$ in acid medium); detn. of Ca turbidimetric method of Butirina (reagent is mixture of $NH_4Cl + NH_4C_2O_4$, 1:1); and detn. of Mg^{++} by the Butirina method by using a mixture of $NH_4Cl + NH_4NaHPO_4$, 1:1. The method is useful for chem. analysis in field circumstances within 6% exactness. These analyses can be used for hydrochem. characterization of water-bearing horizons, structure of hydrochem. profiles, and preparation of hydrochem. maps in gradations.—CA

A Modification of Knudsen Method for Salinity Determination. J. W. VAN LANDINGHAM. *J. Conseil. Conseil Permanent Intern. Exploration Mer*, 22:174 ('57). The loss of indicator sensitivity and difficulties in the Mohr titration for chlorides in sea water can be eliminated by using adsorption indicators. A new adsorption indicator method for detg. salinity of sea water is described and recommended for use by marine chemists. The modified Fajans method is compared with the standard Mohr method and a table of performance data for both techniques is given. Routine detn. follows the Knudsen method, with the exception of the indicator.—CA

Determination of Calcium, Magnesium, and Hardness of Water With the Aid of Complexon III. G. IVANOV. *Khim. i. Ind.* (Sofia), 31:3:83 ('59). The following reagents are needed: $0.05N$ $CaCO_3$ (2.5025 g. dried, pure $CaCO_3$ dissolved in 3-6 ml concd. HCl, brought to 1 l with distd. H_2O); $0.05N$ $MgSO_4$ (3.009 g dried to const. wt., dissolved in distd. H_2O to 1 l); $0.05N$ complexon III (9.3 g to 1 l with distd. H_2O); NH_4 buffer soln. (100 ml, 20% NH_4Cl mixed with 100 ml, 20% NH_4OH brought to 1 l with distd. H_2O); Eriochrome Black T (0.5 g dissolved in 10 ml NH_4 buffer, dild. to 100 ml with pure alc. or 1 g and 99 g NaCl ground together); and murexide (1 g and 99 g NaCl ground together). For detn. of the titer of complexon III 75 ml $0.05N$ $CaCO_3$ and 25 ml $0.05N$ $MgSO_4$ are mixed and brought to 1 l with distd. H_2O . To a 100-ml aliquot, 5 ml NH_4 buffer and 5-7 drops Eriochrome Black T are added, and the mixt. is titrated to blue-green end point with complexon III. The detn. of Ca in H_2O is based on the property of Ca^{++} to unite with unstable complex compds. in the presence of purple murexide, which changes to bright red. Titrating the complex soln. in $2N$ NaOH, the complex is destroyed and murexide changes back to purple. To a 50-ml sample of H_2O is added 25 ml distd. H_2O , 1.5 ml $2N$ NaOH, and 30-40 mg murexide, and the mixt. is titrated with complexon III. If in the analysis more than 8 ml complexon III is used, a 25-ml sample is dild. with 25-50 ml H_2O and made alk. with 1 ml $2N$ NaOH/50 ml soln. If less than 1 ml complexon III is used, the sample size is increased to 100-200 ml and not dild. Ca is calcd.: $x = [a(0.001)(1000)]/V$, where x

(Continued on page 74 P&R)

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(Continued from page 72 P&R)

= Ca in mg/l H_2O , a = ml complexon III, 0.001 = quantity in g Ca, equiv. to 1 ml complexon III, and V = vol. of sample. The detn. of Mg in H_2O is based on the property of Mg and Ca at $pH \cong 11.5$ in NH_4 buffer to form a wine-red color with Eriochrome Black T. Titrating with complexon III, Ca, and Mg form stable complex compds., while Eriochrome Black T is destroyed, changing to blue-green. To a 50 ml of sample H_2O is added 25 ml distd. H_2O and 5.0 ml NH_4 buffer; the mixt. is titrated with complexon III. The same corrections apply as for the Ca detn. The results obtained are for Ca + Mg. Ca must be run separately and subtracted. Mg is calcd. as $x = [((a(0.05) - (1000)))V - M] 0.01216$, where x = Mg in mg/l H_2O , a = ml of complexon III, V = vol. of sample, 0.05 = conversion to change ml of soln. to meq., M = meq. Ca/l H_2O , and 0.01216 is the meq. wt. of Mg. To det. the overall hardness, meq. Ca + Mg/l H_2O as detd. by the method for Mg is multiplied by 2.8.—CA

Determination of Iodide in Natural Water. CHIN-YUN LEI & KING-SHENG CHOU. *Hua Hsueh Shih Chieh*, p. 127 ('59). The so-called I index has been important in geol. searching for petroleum. Iodide is oxidized to iodate by Br water, the excess of which is removed by $HCOONa$. KI is then added to convert iodate into I which can be detd. by its reaction with starch in H_2SO_4 . The colored I -starch complex is, however, unstable in H_2SO_4 . In this article, instead of H_2SO_4 , H_3PO_4 is used for acidification so that the color is stable, and 20 min are allowed for its detn. Iodide detd. ranges from 0.1 to 1 γ/l with an error of less than 1%. Cl^- , Br^- , and ferric ions present in water samples do not interfere.—CA

Separation and Determination of Microgram Quantities of Molybdenum in Natural Waters. K. SUGAWARA; M. TANAKA; & S. OKABE. *Bul. Chem. Soc. Japan*, 32:221 ('59). The present authors have elaborated a new method of detn., applicable to both sea and fresh waters, by which they plan to conduct an extensive study of the distribution of Mo in various kinds of natural water. Depending upon the probable content of Mo, a sample of 1–5 liters is taken. After being warmed to 70–80°, the sample is acidified with HCl . The soln. is then neutralized with 4N $NaOH$ soln. to bromocresol purple, buf-

fered to approx. pH 3.8 by addn. of 12 ml glacial $AcOH$ and 5 ml 4M $AcONa/l$, 2 ml $MnSO_4$ soln. (1 g/100 ml), and 2 ml $KMnO_4$ soln. (0.86 g/100 ml), added successively with vigorous stirring, the soln. heated to 80° whereby coagulation of the hydrated oxide of Mn is hastened. After cooling, the coagulant is filtered, then dissolved in a small amt. 2N HCl contg. 1 ml 1% H_2O_2 , the soln. boiled gently 30 min until the excess of H_2O_2 is expelled, the soln. cooled, 1 ml 10% Na_2SO_3 added whereby the remaining H_2O_2 is decompd. and ferric ions are reduced, further addn. of 10% KI soln. ensures elimination of traces of H_2O_2 and the ferric ion, and the liberated iodine is driven out by heating 10 min. on a water bath. The final vol. of the soln. is 10–15 ml. Two ml concd. HCl , 2 ml $Fe(NH_4)_2(SO_4)_2$ soln. (0.70 g/100 ml), and 3 ml 10% $KCNS$ soln. are successively added, and the whole shaken with 3 ml $SnCl_2$ (10 g/100 ml N HCl) soln. The resulting Mo thiocyanate is extd. with 7 ml and then with 2 ml of $BuOH-CHCl_3$ mixt. (1:4), and the joint exts. are adjusted to 10 ml. A few mg of solid $SnCl_2$ are added to protect the ferrous iron against oxidn. The absorbance measurement is then made at 475 $m\mu$. The Mo detn. is made in reference to the standard curve previously prepd.—CA

Titrimetric Determination of Free CO_2 in Water. O. THOMANN & A. SCHERRER. *Mitt. Gebiete Lebensmitt. u. Hyg. (Ger.)*, 50: 186 ('59). Instead of phenolphthalein, mixed indicator composed of thymol blue and 1-naphtholphthalein is used in the standard titration with $NaOH$ or Na_2CO_3 to det. free carbonic acid. The end point is more clearly discerned, and values of ± 1 ppm CO_2 are distinguishable in 100-ml water samples.—CA

Neutralizing of Acid Waters With Powdered Carbonates. J. LESENYEI & I. TOOKOS. *Beszamolo a Vizgazdalkodasi Tudomanyos Kutato Intezet Munka-jarol (Hung.)*, p. 240 ('59). Neutralizing expts. were carried out in lab. with powdered $CaCO_3$, 2 kinds of limestone powders, and dolomite powder. The acids were used in the concns. of 0.1, 0.5, 1.0, 2.5, and 5.0%. With HCl the effect is best if the neutralizing substance has a mesh size >1 mm and the CO_2 excess is 10%. The reaction time is a few min. For H_2SO_4 the reaction time is very long; the CO_2 excess required is high, and the mesh

(Continued on page 76 P&R)

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(Continued from page 74 P&R)

size must be small. HNO_3 requires a small mesh size and a medium reaction time (15 min).—CA

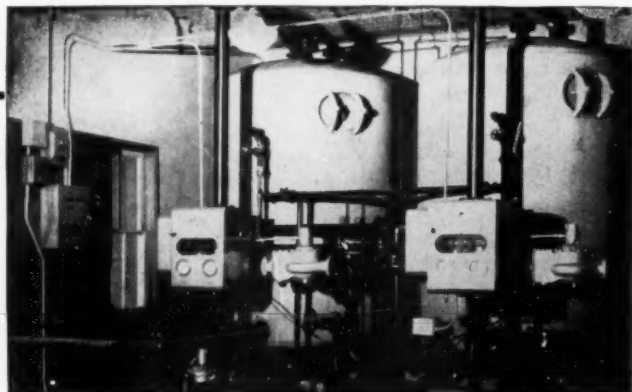
Techniques for Measurement of Hydrogen Sulfide and Sulfur Oxides. M. B. JACOBS. *Natl. Acad. Sci.—Natl. Research Council, Publ.*, 652:24 ('59). Among the most important air pollutants are S-bearing components, principally SO_2 , SO_3 , H_2SO_4 , and H_2S , and possibly S_2O_7 and H_2SO_5 . A no. of anal. methods are given for some of these compds. For H_2S , the CdS or methylene blue method can be used. In the former, the amt. of CdS pptd. in weakly acid or ammoniacal soln. is estd. iodimetrically, and then the amt. of H_2S can be calcd. In the latter, sulfide ion reacts with a mixt. of *p*-aminodimethylaniline, and ferric and chloride ions to yield methylene blue. SO_2 can be detd. by any of a no. of methods, namely, sulfate, H_2O_2 , I, fuchsin, $\text{I-S}_2\text{O}_8$, disulfite-mercurate, PbO_2 cylinder, and cond. For SO_3 , the BaSO_4 or filter-paper methods may be used. In the BaSO_4 method, SO_3 and H_2SO_4 are caught in NaOH soln., and the excess alkali is titrated with HCl. The

sulfate is then pptd. with BaCl_2 , and BaSO_4 is estd. in the usual manner. In the filter-paper method, specially prepd. filter papers are used to trap H_2SO_4 mist, the acidity then being detd. by titration.—CA

Indicators With Internal Light Filters.

I. Determination of the Hardness of Weakly Mineralized Waters With the Use of Hydron 1. I. S. MUSTAFIN & E. S. KRUCHKOVA. *Izvest. Vysshykh Ucheb. Zavedenii, Khim. i Khim. Tekhnol. (USSR)*, 2:3:311 ('59). Following indicators have a less extended transition than Eriochrome Black T (I): Diamond Black P V, 0.05, 0.5, 11, pink to blue; Acid Chrome Black F, 0.05, 0.25, 11, red to blue; Chrome Fast Blue FB, 0.1, 0.5, 10, violet-pink to blue. These substances can be used with internal light filters, such as Naphthol Yellow (II), Tropeolin O, and 1-nitroso-2-naphthylamine. II in aq. soln. has a well-defined absorption max. in the lowest wave-length part of the visible spectrum. The extinction molar coeffs. ($\epsilon \times 10^{-4}$) of the following dyes and their Mg complexes are given: I, 1.76, 1.84; Acid Chrome Dark Blue, 0.82, 1.04; Acid Solo-

(Continued on page 78 P&R)



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WOODWARD, ALABAMA

(Continued from page 76 P&R)

chrome Blue 3 (III), 1.32, 1.92. Consequently, III should be the most active reagent for Mg. The mixed indicator, consisting of III and II, gives, at a pH of about 10, a green soln., but in the presence of Mg and Ca ions, the color instantaneously changes to red. Hydron 1 (IV), a mixed indicator consisting of Acid Solochrome Blue 3 and II, reacts with Ca^{++} with a remarkably greater sensitivity than other indicators: 0.012 γ/ml Ca^{++} can be detected. Sr^{++} , Ba^{++} , Zn^{++} , Cu^{++} , Na^{+} , and Co^{++} also react like Mg^{++} and Ca^{++} with IV at pH 10; however, the compds. with Mg^{++} and Ca^{++} are not destroyed with Trilon B. Al and Fe under the conditions of analysis form the hydroxides, and, when present in concns. of up to 5 mg/l, do not interfere in the detn. of Mg^{++} and Ca^{++} ; however, they should be removed when present in greater amts. IV permits the detn. of the hardness of waters by titrating with 0.005N Trilon soln. (for a hardness 0.01 mg equiv./l, a 0.002N soln. should be used). The degree of salinity of waters having a hardness of the order of a few γ equiv./l can also be detd. with satisfactory accuracy. IV is prepd. by mixing 2 vols. of 0.5% alc. buffered soln. of III and 3 vols. 0.25% aq. soln. II; the former soln. is prepd. by dissolving 0.5 g III in 10 ml buffered soln., at pH about 10, bringing the vol. to 100 ml with an EtOH distillate, heating almost to boiling, cooling, and filtering through cotton wool. The mixed solns. do not change on standing.—CA

Determination of Trace Elements in Natural Waters by Preliminary Enrichment, Using the Particle Sedimentation Method. V. B. ALESKOVSKII, ET AL. *Trudy Leningrad. Tekhnol. Inst. Im. Lensovetu*, 48:12 ('58). The ion-exchange method used for the enrichment of trace quantities of elements in natural waters was developed. A finely divided cation exchanger, such as $\text{Al}_2\text{O}_3 \cdot 5\text{SiO}_2 \cdot n\text{H}_2\text{O}$ was pretreated with HCl and then dispersed in the water to be analyzed. After 15–20 min the sedimented particles were sepd. from the water and were washed with a 15% HCl soln. and with hot water. In the concentrate of the wash liquid, γ/l quants. of Cu, Pb, Ag, and Zn were detd. by colorimetric methods. For 1 liter of water about 20 g of the adsorbent with a particle size of 0.10–0.15 μm was found to be sufficient. The presence of Ca, Mg, Na, and Fe was found to be favorable

for the complete adsorption of the Cu^{++} ions. Field tests of water samples from wells and springs penetrating through metal-bearing limestone showed anomalously high heavy metal content: Zn 50–80, Cu up to 20, and Pb 30 γ/l , while the overall hardness of the water did not exceed 10 $\mu\text{eq}/\text{l}$.—CA

New Methods of Serial Determination of Phosphate and Aluminum for Hydrobiological Water Analysis.—The Aluminum Content of Lake Balaton and Brooks of This District. BELA ENTZ. *Magyar Tudományos Akad. Tihanyi Biol. Kutatóintézetek Ezkonyve* (Hung.), 25:173, 8 ('57-'58). To det. PO_4 , add 1 cc 2.5% $(\text{NH}_4)_2\text{MoO}_4$ in 5N H_2SO_4 and 0.2 ml 0.25% 1-amino-2-naphthol-4-sulfonic acid (prepd. with 15% NaHSO_3 and some Na_2SO_3) to 5 cc H_2O , fill up to 10 ml in a test tube with a ground glass stopper, incubate at 37° for 10 min, and compare the color with a known sample. To det. Al^{+++} , add 0.4 ml 10% HCl and 1 drop satd. KMnO_4 soln., and decolorize after 10 min with 0.4 ml 20% KSCN soln. If Fe is present, colorimetrically evaluate the pink soln. Then eliminate the Fe color by adding ascorbic acid. Then add 1.2 cc acetate buffer soln. and 0.4 ml 0.1% aluminon soln., and, after 1½ hr standing, compare the developed color with known solns. The Al content of the Lake Balaton and its brooks is 26–33 γ/l near the shore and 12–21 γ/l elsewhere.—CA

Determination of Chlorine Dioxide in Treated Surface Waters. M. A. POST & W. A. MOORE. *Anal. Chem.*, 31:1872 ('59). For ClO_2 concns. of 0.05–1.5 ppm reaction with purified H acid soln. produces a bluish-pink color, which is proportional to the ClO_2 concn. and which can be measured spectrophotometrically at 525 m μ . Max. absorption occurs at pH 4.1–4.3, obtained through use of an acetate buffer. The presence of 0.01 mg of Fe, as FeCl_3 , increases the sensitivity of the reaction, by deepening and stabilizing the color. Interfering substances are "free" Cl and chloramines which yield similar colors with H-acid, but are prevented from so-doing if malonic acid is added to the buffered sample portion before addn. of the H-acid. Chlorites also interfere, and they cannot be distinguished from ClO_2 since they decomp. to form ClO_2 at pH 4.2. A study of 18 diverse ions encountered in treated water indicates that nitrite ion in

(Continued on page 80 P&R)



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excess of 0.5 ppm causes a pos. error (a method of eliminating NO_2^- interference is mentioned). Polyphosphates also interfere appreciably, but the mechanism of the interference, or its elimination, has not been detd. It is suggested that the standard curves used be prepd. with water contg. the customary concn. of polyphosphate. Satisfactory recovery results for ClO_2 added to various types of water (e.g., tap, deep well, and river), made demand-free, indicate the procedure is practical and well-adapted to different types of water. Details are given for (1) the detn. of ClO_2 in water contg. no "free" Cl, or chloramines, (2) the detn. of ClO_2 in water contg. free Cl, or chloramines, (3) the detn. of "free" Cl in water contg. ClO_2 , and (4) the detn. of ClO_2 in water contg. suspended matter. In (1) the color developed when 0.40 ml of H-acid soln. is added to 90 ml of water sample, to which 0.01 mg Fe(III) and 5 ml acetate buffer soln. (pH 4.1 to 4.3) were previously added, is measured spectrophotometrically at 525 m μ ; and the ClO_2 concn. of the sample is detd. from a previously prepd. standard curve, based on known concns. of ClO_2 (range 0.05–1.5 ppm). In (2) the procedure is similar to (1), except that 0.002 g of malonic acid is added prior to the H-acid soln. addn. In (3), readings by procedure (2) are deducted from apparent readings by procedure (1), the net reading being equiv. to free Cl in the sample, which can be related to concn. of free Cl in the sample by reference to previously prepd. curves. In procedure (4), sediment is 1st removed by flocculation with ZnSO_4 plus NaOH, an aliquot of the supernatant being used for the detn. of ClO_2 by procedure (1) or (2), as appropriate.—CA

Contribution to the Theory of p and m Values. H. E. HOEMIG. *Mitt. Ver. Grosskesselbesitzer* (Ger.), p. 170 ('57). The potable-water method, devised from classical water chem., for the detn. of bicarbonate and carbonate by the detn. of p and m values gives false results at high dilns. For the idealized system $\text{NaOH-CO}_2\text{-H}_2\text{O}$, it is shown that p and m values have only limited application for hydroxide, bicarbonate, and carbonate, and that where the values are <1 , they are to be discarded; for higher values a considerable error is involved. The total CO_2 concn. and pH of the soln. make a reliable calcn. of the concns. of HCO_3^- and CO_3^{2-}

possible even when bases other than NaOH are present.—CA

BACTERIOLOGY

Threshold Concentrations of Different Sources of Nitrogen for the Development of Some Bacteria From Waters Poor in Nutrient Matter. H. W. JANNASCH. *Arch. Mikrobiol.* (Ger.), 31:114 ('58). Various sources of nitrogen (ammonium chloride, potassium nitrate, Bactopectone, and mixt. of amino acids) were tested to detn. the min. concns. inducing growth in liquid cultures of *Flavobacterium aquatile*, *Acrobacter aerogenes*, and *Bacillus subtilis*. Multiplication was judged by plate counts and microscopic counts on membrane filters. The lowest concn. of nitrogen at which multiplication occurred varied from 1–500 $\mu\text{g/l}$, depending both on the source of nitrogen and the organism used. *A. aerogenes* required higher concns. of nitrogen than the other 2 organisms. Threshold concns. were lower with ammonia and hydrolyzed peptone as sources than with nitrate and untreated peptone. Measurements of cell size indicated, with *B. subtilis*, formation of cell material at concns. of ammonia-nitrogen lower than those necessary for multiplication.—WPA

Nitrogen Fixation by Gram-Negative Bacteria. M. H. PROCTOR & P. W. WILSON. *Nature* (London), 182:891 ('58). Research has been carried out to investigate the nitrogen-fixing properties of strains of *Pseudomonas* and *Achromobacter*, common in soils and surface waters, isolated under non-selective conditions. The sensitive tracer nitrogen-15 technique and the more conventional Kjeldahl method were employed, ammonium and nitrogen ions being added to the basal medium as required. The composition of the basal medium is given. Aerobic fixation was demonstrated in 6 strains of *Pseudomonas* and 8 strains of *Achromobacter*. All the strains of *Pseudomonas* except *Ps. azotogenes* were also capable of anaerobic fixation, but only Jensen's strain of the *Achromobacter* fixed in the absence of oxygen. In both genera, nitrogen fixation appears to be controlled by an inducible enzyme system. In view of the widespread occurrence of both these genera in soil and surface waters, their ability to fix nitrogen may be of considerable importance.—WPA

(Continued on page 82 P&R)

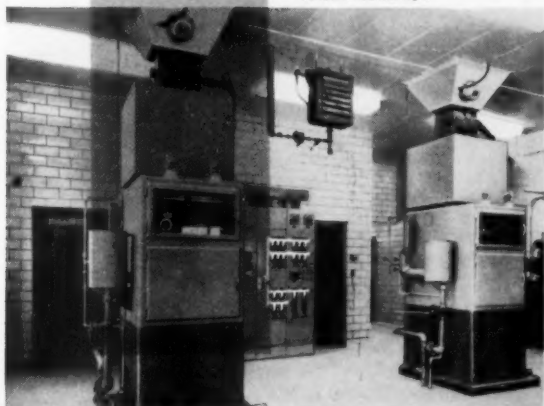
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(Continued from page 80 P&R)

Some Effects of High Concentrations of Anionic Surface-Active Substances on Bacteria. W. K. FISCHER. *Arch. Mikrobiol.* (Ger.), 31:33 ('58). Investigation is described into the action on bacteria of anionic surface-active substances. Expts. were made on the resistance of Gram-negative and Gram-positive bacteria as measured by inhibition of oxygen uptake, the limiting concns. for inhibition of oxygen uptake and for destruction and their relation to the critical concn., the action of the substances in the region of physiological limiting temps., the specific differences in resistance of 2 strains of *Mycobacterium phlei* and their possible connection with catalase activity, and the mode of action on the bact. cell. The percentage inhibition of oxygen uptake, measured manometrically, represented accurately the difference in resistance of Gram-negative and Gram-positive bacteria to high concns. of anionic surface-active substances. The methods used and results obtained are described and discussed.—WPA

Investigations on the Bacterial Oxidation of Benzole—I. Evidence and Chemistry of the Decomposition of Benzole. T. WIELAND; G. GRISS; & B. HACCUS. *Arch. Mikrobiol.* (Ger.), 28:383 ('58). Authors describe investigations into the bact. decomposition of benzole, dealing in the first part with the isolation and culture of the organism used and the chemistry of the decomposition of benzole. The organism used was isolated from a sandy loamy arable soil freshly manured with pig dung. The strain, known as M 5, is similar in morphological and physiological properties to certain strains of saprophytic *Mycobacterium* and *Nocardia* but belonged to neither type. Respiration measurements showed that the strain decomposed benzole in a relatively short time. Organisms from nutrient agar required, in contrast to organisms from mineral salt soln. contg. benzole, an acclimatization period of at least 30 min before attaining the max. effect on benzole. During oxidation transmuconic acid could be detected by analysis in the medium. As pyrocatechol was utilized by benzole-adapted organisms immediately and phenol only after an acclimatization period of 4-5 hr, it seems improbable that the process which has been suggested for benzole oxidation by *Micrococcus sphaeroides* (through phenol to pyrocatechol and muconic acid) applies to the organism now

investigated. Direct oxidation of benzole to divalent phenol (pyrocatechol) is assumed. Attempts to extract a benzole oxidase were unsuccessful; only a yellow soln. contg. protein was obtained, in which, in addition to catalase, a pyrocatechol oxidase but no phenol oxidase was found.—WPA

LABORATORY METHODS

Apparatus for Total Analysis of Distillation Water in One Process. B. MEISSNER. *Wasserwirtsch. & Wassertech.*, 6:305 ('56); *Literaturber. Wasser Abwasser Luft & Boden*, 7:39 ('58). Apparatus is described and illustrated by which hydrogen sulfide, sulfurous, acid, organic acids, mono- and polyvalent phenols, alcohols, ammonia, and nitrogen bases can be detd. in brown coal distillation water in one process. Method saves time and makes it possible to introduce full analysis in routine supervision of phenol removal and phenol destruction plants.—WPA

Problem of Fluoride Determination in Drinking Water. J. MAYER & E. HLUCHAN. *Chem. Zvesti* (Czech.), 12:143 ('58). Various methods for determination of fluorides in drinking water were compared, and the effects of interfering ions were studied. Most satisfactory method appeared to be direct titration with thorium nitrate, using Alizarin Red as indicator, with some modification after eliminating interfering sulfates as barium sulfate.—WPA

Radioactive Method of Measuring Low Water Flow Rates. J. CAMERON; P. BERRY; & F. TAYLOR. *British Chem. Eng.*, 4:7b (Feb. '59). Discusses design of a flowmeter for measuring fluids at very low flow rates and at high pressures.—PHEA

A New Process for the Manufacture of Chlorine Dioxide. W. H. RAPSON. *Tappi*, 41:181 ('58). In a process for continuous production of chlorine dioxide, a conc. soln. contg. sodium chlorate and sodium chloride, in equimolar ratio, and a separate stream of conc. sulfuric acid, are passed together through a corrosion-resistant tank. Chlorine dioxide and chlorine are produced in a 2:1 molar ratio, and are removed from soln. by a stream of air which agitates soln. and dilutes gas to a safe concn. Chlorine dioxide may be separated from chlorine by preferential absorption in water. Spent soln.

(Continued on page 84 P&R)

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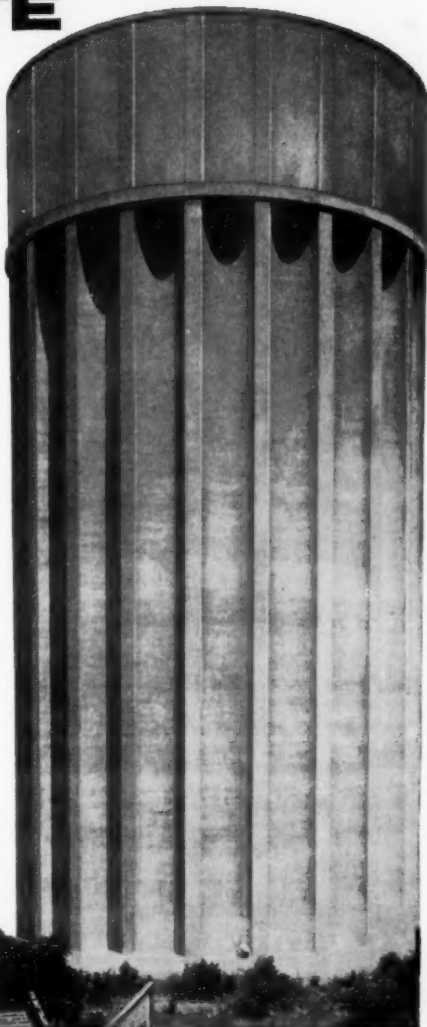
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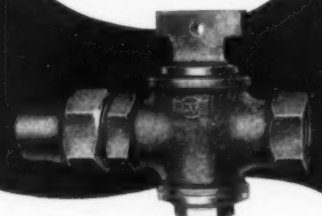
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can be discharged or treated for recovery of chemicals. Process is efficient and economical.—WPA

Investigations on Use of Nutrient Cardboards for Bacteriologic Examination of Water by the Membrane Filter Method. D. THON & A. BELING. *Zeit. f. Bakt. I. Abt. Orig.*, 172:3/4:282 ('58). Authors tried to improve bact. examn. of water by MF method by incorporating nutrient in disks of cardboard. Filter cardboard was soaked with nutrient media, sterilized, and dried. Paper describes properties of nutrient disks of cardboard and how they are used. Results of tests concerning specificity, sterility and comparison with agar nutrient media are also given. Dried cards of nutrient medium do not deteriorate for months and are therefore especially suited for small labs. and field trials. Experience over some years showed that nutrient cardboards used in combination with membrane filtration gave both consistent and reproducible results.—PHEA

Comparative Tests of Certain Media Proposed for the Determination of Coliform Organisms in Water. G. GABBRIELLI & G. GIUNTI. *Nuovi Ann. Igiene e Microbiol. (It.)*, 8:525 ('57). Expts. were carried out to compare, by 3 different methods, efficiencies of lactose broth, MacConkey broth, and lauryl sulfate broth for detection of coliform organisms in water. From results, which were analyzed statistically, it is concluded that MacConkey broth is not a suitable medium for presumptive tests, and use of lauryl sulfate broth is recommended.—WPA

SALINE WATER CONVERSION

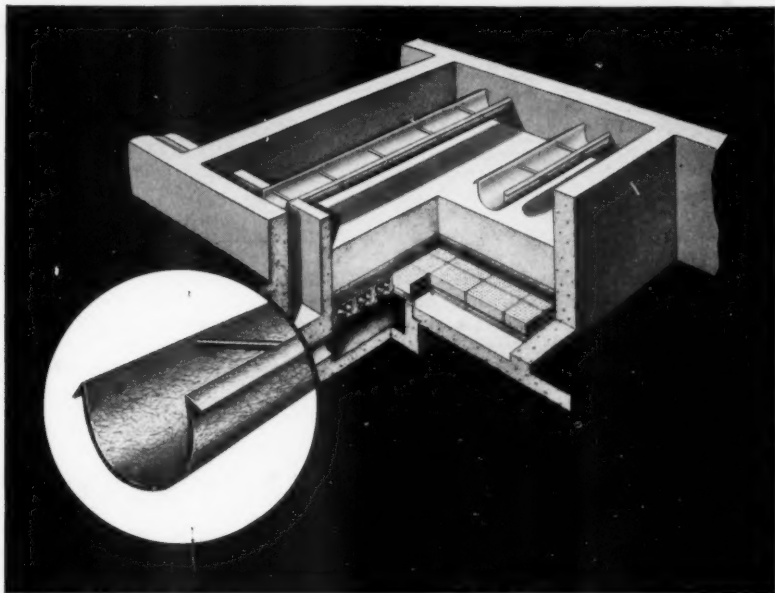
Ion Exchange: The Present and the Future. T. R. KRESSMAN. *Indust. Chem. Mfr.*, 34:333 ('58). Recent developments in 3 methods of ion exchange, namely membrane electrodialysis, continuous ion exchange, and the resin-in-pulp process, are reviewed. Membrane electrodialysis is now mainly used for the demineralization of brackish water, although it is not yet known with certainty how successfully the process may be operated; continuous countercurrent ion exchange is primarily used for water softening, but further work on this process is necessary

(Continued on page 86 P&R)

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before it will replace the conventional ion-exchange column; and the resin-in-pulp process is used for the recovery of uranium from its ores, and may in the future be used for the recovery of other metals from their ores.—WPA

The Electrodialysis Process. B. A. COOKE & W. G. MANDERSLOOT. *Trans. Inst. Chem. Engrs.*, 37:14 ('59). The principles of electrodialysis are discussed, particularly the process using ion-selective membranes in a multicell arrangement, and the phenomena of polarization, coulomb efficiency, energy consumption, water transfer, competing ion transfer, and co-ion transport are considered. In the extended operation of an electrodialysis plant, deleterious effects can occur owing to scale formation; coag. of colloidal material, which is however easily removed by abruptly changing the rate of flow of liquid to the affected parts of the plant; and uptake of multivalent ions, such as trivalent iron, which reduces the selectivity and conductance of the membranes. Examples are given of the application of

ion-selective electrodialysis, including the demineralization of water and the treatment of waste waters such as radioactive waste waters and sulfate pickle liquor.—WPA

Electrodialysis for Purifying Brackish Water Supplies. W. M. BOBY. *Surveyor* (London), 118:65 ('59). In a paper presented to the Institution of Public Health Engineers, Jan. '59, the author explained the principles of electrodialysis and discussed its application to the desalting of brackish water contg. up to 15,000 mg/l dissolved salts. The principles of the 2 basic types of electrodialysis plant (tortuous-path and perforated-separator types) are compared with the aid of diagrams. The operation of an electrodialysis plant is explained; methods for reducing wastage of water are given; and troubles due to corrosion, to deposition inside the membrane stack, and to bact. growth in the membrane cells are considered. A flow sheet for a batch-type electrodialysis plant of the perforated-separator type is included; work is proceeding on the development of continuous processes.—WPA

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Demineralization and Organic Substances

—I. P. F. BOGERS. *Bul. Centre Belge Et. Document. Eaux* (Liege), 40:112 ('58). The water supply at Eindhoven, to be used for makeup water at a new power station, is drawn from beds 90-100 m deep and is treated by sand filtration. Preliminary tests on the demineralization of the water in cation and mixed-bed ion-exchange units showed that difficulties are caused by the organic compds. in the water. Various methods for removing these compds. were tested and the method finally adopted involves the use of a very porous, strongly basic resin such as A259 (an Activit product). A flow diagram showing the treatment of water at the power plant is included. Cooling water from the generator and fresh water as required is passed through filters containing A259, cation-exchange units, a column for removal of carbon dioxide, and mixed-bed ion-exchange units. Condensate is treated by passage through Amberlite IR120 and Amberlite IR45. Before removal of oxygen all boiler feedwater is treated with ammonia and trisodium phosphate. Limits for the pH value and the contents of oxygen, silica, chlorine, and total solids are given. During operation for 2 yr the results have been satisfactory and no corrosion has occurred.—WPA

Demineralization and Organic Substances

—II. The Absorption of Humic Acids by Anionic Exchange Materials. G. J. JONG & J. C. JANSEN. *Bul. Centre Belge Et. Document. Eaux* (Liege), 40:119 ('58). Authors discussed the mechanism of the so-called "absorption" of humic acids on anionic-exchange materials and described a method for preparing a concd. soln. of humic acids and expts. using this soln. to investigate the capacity of different exchange materials to absorb humic acids and the factors affecting the regeneration of these materials. Results are given diagrammatically and discussed. It is concluded that it is advantageous to use ion-exchange materials of low density. The normal method for regenerating anionic materials with caustic soda removes little of the humic acids even when using porous anionic materials. A 10% soln. of caustic soda is more effective than weaker solns., but the results are still not satisfactory. The resins can be regenerated with a warm 10% soln. of sodium chloride. The mechanism of this reaction is discussed. To avoid the

effects of humic materials during demineralization, the water can be subjected to a prelim. treatment on strongly basic ion-exchange material in chloride form.—WPA

Membranes With Selective Permeability for Cations.

N. V. STAMICARBON. *Chem. Zentr.* (Ger.), 128:9481 ('57). Prepn. is described of membranes from ethylene or mixed polymers which are treated dry with sulfonating agents, like chlorosulfonic acid, at 0-50°C (preferably 30°-40°C) until their elec. resistance per sq dm is less than 1 ohm. Plates or tubes can be sulfonated. The membranes can be used for demineralization of sea water.—WPA

Ion Exchange.

R. KUNIN & G. BODAMER. *Ind. Eng. Chem.*, 51:373 ('59). This review and discussion of recent publications on ion exchange contains references to the theory of ion exchange, its applications including the treatment of water (particularly the use of the monobed technique for treating water for electricity generating plant operating at high pressures) and waste waters, new ion-exchange materials, and membrane processes, particularly the multiple membrane cell process for treating brackish and sea water (with examples of its use in South Africa, the Netherlands, England, and California). Reference is made to the increasing use of ion exchange in the atomic-energy industry, including the treatment of water and wastes, and the recovery of uranium from leach liquor by liquid ion exchanges.—WPA

Water Demineralization at the Thermal Station of Alost.

J. BERLO. *Tech. Peau* (Brussels), 13:147:13 & 148:29 ('59). Carbonate is removed in a cyclone where lime water (prepd. from carbonate-free H₂O flowing on CaO) reacts with HCO₃⁻ ions. CaCO₃ crystallizes immediately around the sand grains. Carbonate-free H₂O is then filtered, and softening is obtained in 3 stages. The various com. ion-exchangers are reviewed; Amberlites, IRA 410, and IR 120 are used. The working practice and control, the installation, and the conditioned H₂O storage are described.—CA

Large-Scale Demineralization of Sea and Brackish Water. II. Membrane Processes.

A. M. ESHAYA & B. F. DODGE. *Brit. Chem. Eng.*, 4:516 ('58). Electrodialysis, based on the use of cation- and anion-permeable mem-

(Continued on page 90 P&R)



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Bursting Tensile	25,880 psi	3,430 psi
Impact Resistance	234 ft. lbs.	60 ft. lbs.
Beam Loads (12-foot span)	20,790 pounds	3,060 pounds
Crushing Loads	17,900 lbs. per ft.	6,480 lbs. per ft.
Water Absorption	None	9.8% of weight after 24-hour submersion
Tight Joints	Wide selection for liquid or gas service	Limited selection for water service
Inside Diameter	6.14"	5.85"

Pipe tested were 6" Class 150.

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(Continued from page 88 P&R)

branes, is applied to large-scale water demineralization. Included in the discussion are methods of calculating energy requirements and plant costs and a description of Murphy's osmionic process (*US Office of Saline Water, Saline Water Research and Develop. Prog. Rept. No. 14* ('57)).

III. A Forced-Circulation Dropwise Condensation Vapor Compression Cycle for Large-Scale Desalting. *Ibid.*, 596 ('59). Sea water that enters the plant at 65°F is heated by outgoing waste and distillate streams in auxiliary heat exchangers. Then the feed stream, after entry into the main heat exchanger, flows through the tubes at about 8 fps where it is heated by the steam condensing on the shell side in dropwise fashion. The brine then enters a flash chamber maintained at a pressure slightly lower than the satn. pressure and corresponding to the brine temp. A small fraction of the brine evaporates and passes to a compressor, where its pressure is raised so that it condenses on the shell side of the

heat exchanger and gives up its latent heat to the brine in the tubes. After withdrawal of a waste stream adequate to maintain a fixed concn. in the heat exchanger, the liquid from the flash chamber is recirculated through the main heat exchanger. A discussion is included of the economic effects of variations in brine velocity, temp. approaches in main heat exchanger, fraction of brine flashed/pass, and temp. of evapn.—CA

Zone Freezing in Demineralizing Saline Waters. R. C. HIMES, ET AL. *Ind. Eng. Chem.*, 51:1345 ('59). Basic expts. showing that saline waters can be demineralized by multiple-stage zone freezing were performed. The performance of 2 continuously operating machines is evaluated.—CA

Progress in Saline Water Conversion. J. J. STROBEL. *Chem. Eng. Progr.*, 55:9:126 ('59). Proposed equip. designs and problems involved in saline H₂O conversion are summarized for 5 major types of conversion

(Continued on page 92 P&R)

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Sodium Fluoride - 98%

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tight shutoff possible, but also eliminates shaft sealing problems, permits easy rubber seat replacement or adjustment without removing shaft or operator, and requires less operating torque.

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(Continued from page 90 P&R)

processes: (1) solar distn., (2) sepn. by freezing, (3) membrane processes including electrodialysis, (4) distn. using fuels, and (5) multistage flash distn. Conversion costs are included.—CA

Production of Drinking Water From Radioactively Polluted Water. H. ROSHARD. *Schweiz. Banstg.*, 77:109 ('59). The causes of poln. by atom bomb tests or in war and the danger of the use of such drinking water for more than a limited time are pointed out. For the purification, especially of salt-rich drinking water (as it is mostly the case in Switzerland) equipment with ion exchangers is used. As thereby, however, the mineral constituents are also removed, a subsequent restitution of the necessary salts has to be made. A purification app. is described which combines one or several filtering processes with an ion-exchange process and subsequent salt addn. Expts. showed a reduction of the radioactivity of the water to less than 0.1% of the original value.—CA

Fast-Flow Rate Deionization—Pressure Drops and Removal of Trace Quantities of Metal Ions. B. N. DICKINSON; I. M. ABRAMS; & L. BENEZRA. *Ind. Eng. Chem.*, 51:1051 ('59). Expts. with mixed resin beds of strong-acid and strong-base exchangers (Duolite C-20 and Duolite A-101), under conditions of high flow rates, show that trace impurities, such as Co, Cu, and possibly Fe, can be effectively scavenged from low-solids waters and boiler condensates.—CA

WELLS AND GROUND WATER

Determination by Carbon-14 of the Age of Ground Water. R. BRINKMANN; K. O. MUENNICH; & J. C. VOGEL. *Naturwissenschaften*, 46:10 ('59). The authors describe expts. on the detn. of carbon isotopes in different ground waters and the use of the carbon-14 content in assessing the age of ground water.—WPA

Treatment of a Well With Air and Water. R. LANG. *Neue Delwa. Z.*, 5:145 ('58); *Zbl. Bakt.*, I, Ref., 169:591 ('58). Plant is described by which first compressed air and then air and water were forced into a well filter and into the surrounding gravel which

had become choked. The process was repeated over the whole length of the well filter with satisfactory results.—WPA

Polyphosphates and Restoration of Old Wells. M. R. LAROSE. *Industr. Aliment.* (Paris), 72:415 ('55); *Chem. Zbl.*, 128:11402 ('57). The author describes the use of polyphosphates in the treatment of industrial water supplies. In general, addn. of 2 mg/l polyphosphate suffices. In very hard water, calcium carbonate incrustations are dissolved by addn. of 4 mg/l. Polyphosphates have also anticorrosive properties, preventing pptn. of iron and forming a protective film on the metal. Their dispersive properties are used in the flotation of minerals, pptn. of clays, and removal of sludge from pipes, wells, and boilers. Experiences in French and American factories in the use of polyphosphates for preventing damage by deposition of amorphous silica, calcium carbonate, and colloidal clay constituents in water pipes and wells are also described.—WPA

Use of Radioactive Isotopes in the Study of Ground Water Movement. N. T. BARKER & J. H. GREEN. *Commonw. Engr.* (Australia), 46:7:62 ('59). After a general discussion of the use of radioactive isotopes as tracers, the authors describe the use of bromine-82 (as potassium bromide) in studying the movement of ground water in a part of Sydney, N.S.W., to supply data for the design of building foundations.—WPA

The Detection of Ground Water by Geophysical Methods and by the Measurement of Electrical Resistivity. S.-A. ANKARA. *Tech. de l'Eau*, 12:136:49 ('58). The use of ground water is important in Turkey, especially since the surface waters are pold. The detection of ground water by geophysical methods is discussed, the most important being the method based on detecting the difference in elec. resistivity between aquiferous and non-aquiferous strata. Examples are given of the successful use of this method and the subsequent boring of wells at Orman Çitligi, Akçakale, and Baskuyu. In arid regions, geophysical methods can also be of use in predicting changes in the weather 2 or 3 days in advance.—WPA

(Continued on page 94 P&R)

Painter applies Torex Heavy with short-nap roller. Torex Heavy is a gray, rubber-base coating, giving 2.0 mil thickness per coat, with a flat finish. Imparts no taste or odor to water.



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painted with Inertol[®] to lick rust problem

Solid protection and lower maintenance costs—these were the paint qualities that the Bristol Water Department sought for its 5 MGD filter plant. The Department chose Inertol Company's Torex[®] Heavy for its durability and superior resistance to rust, chemicals and abrasion.

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Mr. J. L. Bean, Managing Engineer of the Bristol Water Department is highly pleased with the performance and appearance of Torex Heavy. Says Mr. Bean, "We just drained the north basin for

inspection. Torex Heavy is doing an excellent job of rust prevention. We found the same good results in our inspection of the south basin."

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(Continued from page 92 P&R)

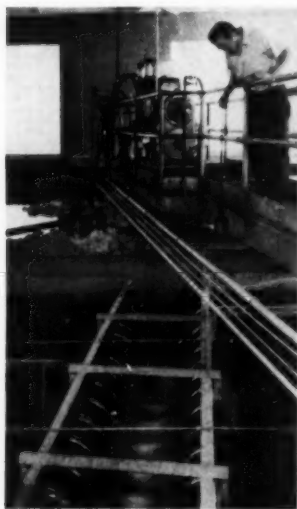
A Ground Water Survey. R. A. DANDO. *Tappi*, 42:1:131A-132A ('59). The Jacksonville, Fla., mill of the St. Regis Paper Co. is located on the St. John's river between 2 tributary streams, all of which are brackish and unsuitable for use as process water. Water was obtained from 2 limestone wells, but when the mill was expanded in 1955 additional water was required. Tests were made on the available ground water, and 5 new wells were drilled into a lower limestone formation which produces a much greater flow of artesian water; these new wells should provide a dependable supply of at least 25 mgd.—WPA

On the Theory of Flow of Underground Fluids in Compressible Strata. A. E. SCHEIDEGGER. *Can. J. Phys.*, 37:276 ('59). The problem of flow of a fluid within a compressible porous medium is discussed. It is shown that in general the motion of the fluid cannot be separated from that of the medium, and this leads to a very complex

problem of consolidation; however, considerable simplification can be made in applications to the flow of underground fluids, where consolidation can take place in the vertical direction only. In addition, it is often possible to neglect the volume compressibility of the porous matrix.—WPA

System for Counting Tritium as Water Vapor. W. F. MERRITT. *Anal. Chem.*, 30:1745 ('58). In a paper presented at the Symposium on Radiochemical Analysis, Div. of Analytical Chemistry, at the 133rd meeting of the American Chemical Society, held at San Francisco, Calif., in Apr. '58, a method for measuring the movement of ground water, by the use of water contg. tritium, is described. Water contg. tritium is counted as water vapor in a heated proportional counter filled with methane. Introduction of the sample is simple and rapid, and mixing by convection with the counting gas is obtained from the heating system. The apparatus is described and illustrated,

(Continued on page 96 P&R)



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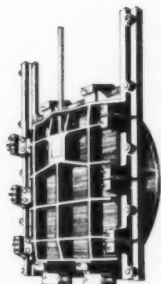
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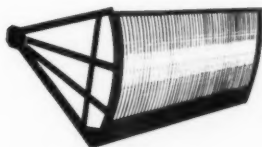
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(Continued from page 94 P&R)

and details of procedure are given. The counter is calibrated using a standard water sample contg. tritium. Good results were obtained with small partial pressures of water vapor at 90°C; some results are presented in tables and graphs. The method was found to be satisfactory, with a standard deviation of +2%.—WPA

SWIMMING POOLS

Artificial Swimming Pools. H. F. HUSTLER. *Good Health*, 107:17 ('58). The author draws attention to some intrinsic problems, including structural and water treatment problems, associated with artificial swimming pools. An outline is given of the medical and bact. aspects to be considered for proper control of swimming baths.—WPA

Swimming Pool Facilities. R. L. FRANCIS. *Off. Bul. N. Dak. Wat. Wks. Conf.*, 26:7:2 ('59). In a paper presented at the 30th Annual Convention of the North Dakota Water & Sewage Works Conference at Dickinson, N. Dak., in October 1959, the author discussed the factors involved in operation of swimming pools, stressing the importance of maintaining the correct pH value and chlorine residuals and describing the recirculation system and the types of filters employed.—WPA

Bathing in the Waters of Large Cities. G. HABENICHT. *Zbl. Bakt.*, I, Ref., 169:359 ('58). A report is given of a paper presented at a meeting of the *Oesterreichische Gesellschaft fuer Mikrobiologie und Hygiene* in Feb. ('58). Arguments for and against bathing in open waters within towns are discussed. Such bathing should not be forbidden unless the results of routine bacteriological examination make it necessary. When there is some risk, which is, however, small in comparison to the advantages of bathing, warnings should be issued.—WPA

Eye Irritation as a Result of Treatment of Swimming Bath Water. B. NIETSCH & H. SLEZAK. *Zbl. Bakt.*, I, Ref., 169:358 ('58). A report is given of a paper presented at a meeting of the *Oesterreichische Gesellschaft fuer Mikrobiologie und Hygiene* in Feb. ('58). Swimming bath water treated to give a pH value of 8.5-9.5 and a chlorine excess of 2.5-3 mg/l may cause eye irritation. Expts. with such a water showed that the effects passed off in about 3 hr and that they were caused by the high alkalinity as well as by the chlorine.—WPA

Improved Hygiene of Swimming Baths by an Overflow Channel on the Schaefer System. A. GAASE. *Staedtchygiene* (Ger.), 9:87 ('58). An illustrated description is given of an improved design of overflow channel for removing surface impurities from swimming baths.—WPA

Is Chlorine the Ideal Pool Water Disinfectant? E. J. LAUBUSCH. *Swimming Pool Age*, 32:26 (Oct. '58). The chlorination of water in swimming pools is discussed as the method of choice in providing a safeguard against health hazards to the bathers. Chlorination is discussed in relation to the source of chlorine, organic matter content of water, the influence of pH on availability, residual free chlorine, and method of application. A continuous method of chlorination is recommended to have effect prior to filtration (prechlorination). Accident hazard due to escape of chlorine gas is pointed out. Pertinent regulations under state laws are reviewed and their variability noted. The leadership given to state regulatory agencies by the Joint Committee on Bathing Places is inferred and the need for uniformity of regulation is stressed.—PHEA

The Use of Suspended Filters in Swimming Bath Operation. W. JUNG. *Arch. Badewesens* (Ger.), 10:184 ('57); *Zbl. Bakt.*, I, Ref., 167:55 ('58). Filters coated with pulverized kieselguhr have recently been used for treating swimming bath water. A number of filter candles are built into the bottom of a pressure-resistant vessel. The candles are 1 m long and 12-15 cm in diameter. The mantle consists of a fine wire spiral or mesh of metal, nylon, or ceramic material. Calcined ground kieselguhr is deposited by water on the outer surface of the candles in a fine layer a few mm thick. In spite of the low filtration rate of 3 m/hr, such a filter can treat, because of its large filtering surface, four times the amount of water treated by a sand filter of the same size. In the treatment of swimming bath water, the capillary action of the filter is quickly stopped by adhesion, but addition of kieselguhr to the water to form a new layer makes it possible to continue operation for runs of up to 8 days. Candles can be cleaned singly by back-washing so that operation can be continuous. The quality of the filtered water is better than with a sand filter, construction costs are the same, and operation costs are 20-40% higher.—WPA

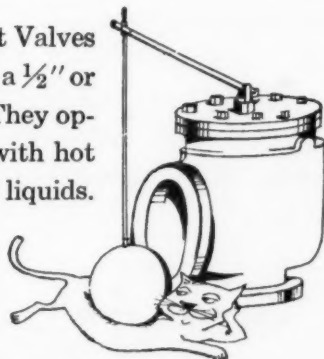
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Sensitive Golden-Anderson Float Valves automatically hold water level to a $\frac{1}{2}$ " or 1" variation in tanks, bins, etc. They operate at high or low pressure—with hot or cold water—and most other liquids.

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Correspondence



Alum Availability

To the Editor:

The joint committee report, "Alum Supply and Use in Water Treatment," in the January 1960 issue (p. 135) has been read with interest. In discussing supply, the committee dealt with the alum stored by water plants rather than the supply available from producers.

Perhaps the reason for the apparent short supply on hand in some filter plants is their proximity to the manufacturing plants. Many of the major water utilities in the United States (Chicago, Philadelphia, Detroit, Cleveland, Denver, Atlanta, St. Louis, Cincinnati, Richmond, Washington, Baltimore) are an hour's distance or less from large producers. The number of aluminum sulfate manufacturing plants in the US is approaching 50 and these are quite strategically located. Their production is continuous and extremely large.

It was felt this comment on the available supply might be of interest, although it was not within the scope of the committee's study.

R. W. OCKERSHAUSEN

General Chemical Div., Allied Chemical Corp.

Edgewater, N.J.; Feb. 1, 1960

A??A

To the Editor:

Though I formerly advocated changing AWWA to AWUA (see Correspondence,

(Continued on page 100 P&R)



Iron and corrosive, odorous gases cause red water, leaky pipes and clogged meters. Unless corrected, these problems will result in loss of revenue, and consumer complaints.

GFC Forced Draft Aerators and Filters can solve these problems. They are designed for easy assembly, dependability and long life.

Ask about our new aluminum and fiberglass Aerators. Write for your copy of our new Aerator and Filter Plant bulletins with design data and problem analyses.

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Correspondence

(Continued from page 98 P&R)

January 1960, p. 94 P&R), I now suggest changing to AQUA, for American Quenching (or Quaffing) Utility Association.

H. A. JANZEN

Kansas City, Kan.; Jan. 22, 1960

* * *

To the Editor:

... Calling it a Utility Association appears to omit all the manufacturers and suppliers. Since three-initial associations are the fashion—e.g., AAA, AGA, AMA, ASA—why not AWA (American Water Association)?

T. R. WERNECKE

Olympia, Wash.; Feb. 3, 1960

(Continued on page 101 P&R)

buried

**The pipe you select
must do the job
under all conditions**

(Continued from page 100 P&R)

Or perhaps the American Water Faucet Utility League—yes, AWFUL.—Ed.

7,000,000 Miles to San Francisco

To the Editor:

Herewith are some assumptions made from your "1959 Conference Statistics" appearing on page 1568 of the December issue.

If all the 3,211 delegates to the San Francisco Conference traveled as directly as possible (as the crow flew), their total mileage would have been in excess of 7,000,000. Actually the figure is probably nearer to 10,000,000 if we consider travel by auto and train, as well as the side trips which many delegates took. At an average cost of 5¢ per mile, the cost of getting delegates to and from the conference is well in excess of \$350,000. That's a lot of dollars to be turning into the cof-

fers of airlines, railroads, oil companies, etc. Wouldn't it be wonderful if the Association could go into the payola racket and get at least a 10 per cent kickback from all transportation companies?

The past 5 years show a continuing increase in the percentage of ladies attending the annual conference, with 24 per cent at San Francisco. In this regard, the 1951 meeting in Miami still holds the record at 25.8 per cent, with the 1954 meeting in Seattle a very close second. Is it a coincidence that all three of these locations are quite a distance from the population center of the country?

E. A. SIGWORTH

New York; Jan. 15, 1960

What Sig is trying to say is that a lot of ladies go a long way.—Ed.



OREGON WASHOUT

A case where floods left steel water line spanning a 50-ft. wide ditch. Line did not fail. Steel pipe continued to carry its own weight and that of water it was transmitting. Southern Pipe Steelcor Products—such as CEMCOTE, mortar lined and coated steel water pipe—are the only products with the hi-beam strength of steel to withstand such tests.

YUMA TERRAIN

A case where rocky terrain and access problems made pipe laying extremely difficult. A select backfill of sand could not be used in ditch. Danger of rupture from settling was obvious. Southern Pipe's own Steelcor product—CEMCOTE, cement mortar lined and coated steel water pipe—was easily handled and laid. Continues to perform.

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A case where truck traffic overhead presented serious vibration problems. Steel's inherent resiliency and strength proved the answer. Unlike rigid pipe, steel transmits strain to surrounding soil. Southern Pipe Steelcor Products—a complete line of lined and coated steel water pipe—provide this performance.

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A case of earthquake with tragic consequences where no other pipe stood up like steel water pipe. Under such emergency conditions steel does the best job; joints don't leak; pipe gives with soil movement. Southern Pipe can help you specify the proper lined and coated steel water pipe to meet all your long-range needs.



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(Continued from page 50 P&R)

'All the Water You Need, When and Where You Need It!' seems to have come off second best with Uncle Sam, or at least with Postmaster General Summerfield, as that pitch and AWWA's 75th Birthday failed to rate a commemorative stamp, whereas this month will see the issuance of a new four-cent stamp celebrating "Water Conservation" (see cut). Of course, we agree with the Soil Conservation Service announcement of the stamp in its indication that: "No other resource so directly affects the welfare, comfort, and happiness of all the people." Where we differ mostly is in the accent on water as a "limiting resource."



In that there is "just so much water," we can agree that it is limited, but it certainly need not be limiting if we but expend the imagination and energy to make it available when and where it is needed.

Actually, defining conservation as making the maximum use of water, we are certainly ardent conservationists, but we get disconserved with such ideas as those of Edmund Gilligan, conductor of the "Rod and Gun" column in the *New York Herald Tribune*, who notes:

Among the most pressing of our social problems is the short supply of water. There's no need of repeating the reports made throughout the country. It's enough

to say that there isn't enough water to serve the ever increasing needs by homes, industries, and, what chiefly concerns us here, the requirements of trout streams and other fishing waters.

The stamp, by the way, is being issued at the Seventh National Watershed Congress in Washington, D.C., on April 18. Contrary to rumor, it *will* require moistening.

Plastic pipe and fittings, of the ABS, PVC, and polyethylene types, are now being offered by Keasbey & Mattison Co., Ambler, Pa., in addition to the company's regular line of asbestos-cement pipe.

The Pennsylvania Water Works Assn., an organization of privately owned water utilities, has changed its name to the Eastern Water Company Conference and will admit members from other states besides Pennsylvania. John H. Murdoch Jr. is president of the group.

Experimental artificial recharge of water-bearing rocks a few miles east of Walla Walla, Wash., has shown the practicability of this means of backstopping the municipal water supply. The experiment was part of a long-term cooperative program of USGS and the Washington Dept. of Conservation to evaluate the state's ground water resources and devise conservation techniques. About 70 acre-ft of creek water was injected, at an average rate of 650 gpm, into a 1,169-ft municipal well penetrating the water-bearing rock formation known to geologists as the Columbia River basalt. The study area is one in which the structure of the rocks limits natural

(Continued on page 104 P&R)



WILLIAM KERIVAN, Chief Filter Plant Operator, Billerica (Mass.) Water Treatment Plant, says:

"Our porous underdrains give completely trouble-free service..."

The Billerica Water Treatment Plant serves 26 square miles, supplying 1.0 MGD from the Concord River. Beds for Billerica's four filters are 30" of sand and 18" of anthracite, with ALOXITE® aluminum oxide porous bottoms. Average load is 1.5 MGD and 2.0 MGD during peak periods.

"What we like most about the ALOXITE plates," says Mr. Kerivan, "is that we have none of the problems of graded gravel. For example, the large photo, taken during backwashing, clearly shows no blow holes such as you run into with an upset gravel bed. Scum is removed easily and uniformly. As for mudballs, they're just a name to us—we don't have them.

"The porous plates have had no repairs since they were installed four years ago. Their only maintenance consists of acid cleaning once a year. Judged from our experience, these bottoms have no shortcomings."

For trouble-free porous media, count on . . .

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Dept. O-40, Refractories Division, Perth Amboy, N. J.

Mrs. Barbara E. Hawkes, Chief Chemist, checks backwashing of Billerica's #1 filter.



(Continued from page 102 P&R)

recharge, and there has been concern over the persistent lowering of water level caused by years of pumping.

The chemical and bacteriologic quality of the injected water was excellent, and it contained only 2 ppm of suspended sediment. Although the quantity of water injected was small, the experiment was successful in showing that artificial recharge of basalt on a continuing basis is feasible.

Some reduction in well yield occurred as a result of the recharging, but it is believed that the loss does not represent permanent deterioration of the well. With a carefully controlled schedule of alternating recharge and pumping, as much as 1,000 gpm may be injected into the well during the 9 months of the year when creek water is available.

A report is to be reproduced for local distribution by the Washington Dept. of Conservation and later published as a USGS water supply paper. Pending reproduction, reference copies are available for inspection at the USGS office in Washington, D.C., and Tacoma, Wash.

Thomas J. Powers, formerly supervisor of waste control for the Midland (Mich.) Div. of Dow Chemical Co., has been named to head the consulting section of Dow Industrial Service, the company's newest division. A member of the water pollution control advisory board of USPHS, he is past-president of the Michigan Sewage & Industrial Wastes Assn.

George W. Cissna, southwest manager, Neptune Meter Co., died Jan. 27, 1960, at Dallas, Tex. Born in LaMonte, Okla., in 1903, he was employed by the Northeast Electric Co.

and Stewart Warner Corp. before joining Neptune as a sales representative. He had been district manager since 1948 and a member of AWWA since 1935.



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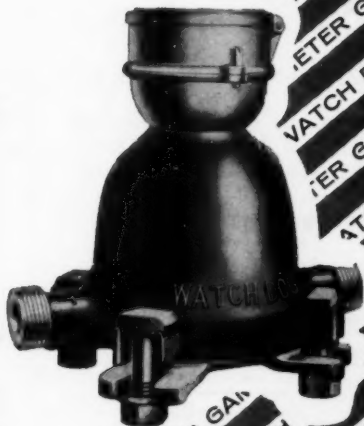
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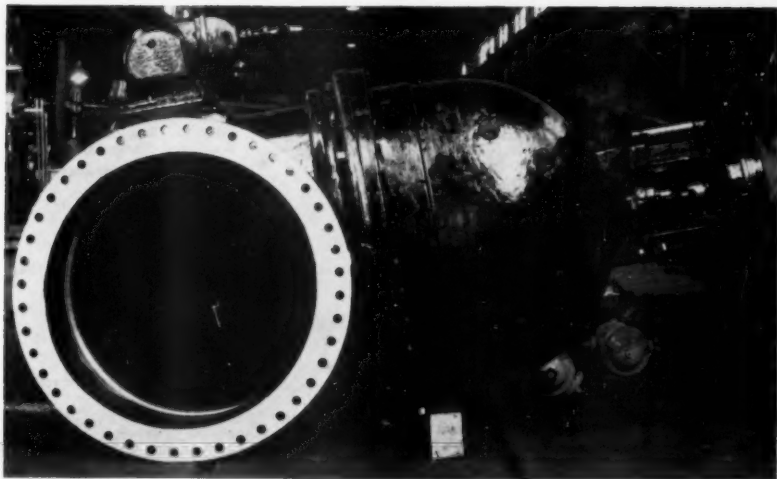
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Ross Valve Mfg. Co., Inc.

Valves, Gate:

James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:

Allis-Chalmers Mfg. Co., Hydraulic
Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:

Allis-Chalmers Mfg. Co., Hydraulic
Div.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:

Allis-Chalmers Mfg. Co., Hydraulic
Div.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
Ross Valve Mfg. Co.

Valves, Swing Check:

James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:

B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.

Waterproofing:

Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div.,
Allied Chemical Corp.

Water Softening Plants; see Softeners**Water Supply Contractors:**

Layne & Bowler, Inc.

Water Testing Apparatus:

LaMotte Chem. Products Co.
Wallace & Tiernan Inc.

Water Treatment Plants:

American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:

Layne & Bowler, Inc.

Well Reconditioning and

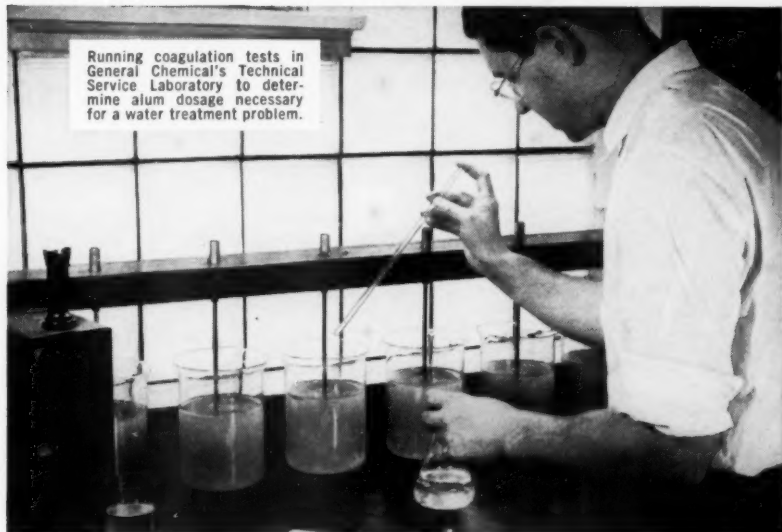
Formation Testing:
Halliburton Oil Well Cementing Co.
Layne & Bowler, Inc.

Wrenches, Ratchet:

Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

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- Suggesting improvements to eliminate existing storing and handling problems.
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- Assisting in laboratory tests and plant trials.
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Dorrco, Flocculator and Squarex—Reg. T.M. U.S. Pat Off.

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